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Le Comité d'organisation de la Conférence aimerait remercier les conférenciers et les animateurs de leur précieuse collaboration.

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WHAT ARE WE THROWING AWAY?

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ABSTRACT

Knowledge of waste composition enables municipalities to develop new management strategies to reduce, reuse, and recycle, as well as to manage residuals. This paper describes a straightforward way to survey the waste being discarded at transfer stations or landfills. It provides reliable estimates of waste composition by combining survey results of both the large items in waste loads with the detailed analysis of smaller samples of each load. This waste survey was tested in four communities in British Columbia, Canada. Composition results of these communities demonstrate the variable nature of waste. The moisture contents of the various waste categories and how these affect composition results are also discussed.

INTRODUCTION

Canada and the United States are committed to the goal of reducing the amount of waste that is discarded. Before we can minimize what we throw away, we need to know more about what we produce. In this way, waste reduction, reuse and recycling programs can be better focused, ensuring that we achieve our goals in an efficient manner.

To assist municipalities in determining the composition of their waste, the British Columbia Ministry of Environment engaged Gartner Lee Limited to prepare a manual which outlines in detail the steps to follow to organize and perform a composition survey. Composition studies carried out regularly will aid the monitoring of local government's progress in achieving the Provincial goal of 50% reduction in weight of waste discarded to landfills by the year 2000.

Testing of the methods outlined in the procedure manual was performed on four typical municipal settings. The settings ranged from:

- an urban area with separate collection of residential and ICI wastes with minimal source separation/recycling programs in place;
- an urban area with separate collections of residential and ICI waste, with a well established source separation/recycling program in place;
- a small community generating mostly residential wastes; and
- rural residential waste.

This paper summarizes both the procedures for composition analysis from "Procedural Manual for Municipal Solid Waste Composition Analysis" (GLL, 1991a) and the results presented in "Determination of MSW Composition of Four Communities in B.C.: Procedures Testing and Results" (GLL, 1991b). A summary of the previous reports is also available as "Municipal Solid Waste Composition Studies" (GLL, 1991c).

I would like to acknowledge Mr. Dave Douglas and Mr. Brian Grant of the B.C. Ministry of Environment for the opportunity to work on these reports. I would also like to thank Mr. Dave Osmond, Director of GLL's B.C. office, and Mr. Paul Murray of GLL's Markham office for their guidance and suggestions.

HOW TO DETERMINE MSW COMPOSITION

A common misconception about waste composition is that exact values need to be determined. The composition of waste varies with the day of the week, time of the year and area of collection. Knowing the exact contents of one waste collection vehicle has limited value since each truck contains different wastes. The methodology used in this study is designed to estimate the composition of a waste stream by estimating the composition of selected loads. By estimating the composition of loads throughout a week–long survey repeated several times throughout the year, estimates of within–week and seasonal variability of the waste are possible.

Waste should be analyzed as it arrives at the disposal site during single–week surveys. Ideally, wastes should come from the entire week being surveyed – including weekends.

For survey purposes, the waste stream is divided into smaller sub–waste streams according to the type of vehicle carrying the waste. Waste on collection vehicles is surveyed separately from waste on private vehicles hauling their own waste. Depending on the waste collection practices of the survey area, the waste stream is further divided into waste from residential and industrial/commercial/institutional (ICI) sources. The total stream is divided into the sub–waste streams described above since the compositions of wastes in these sub–waste streams are more homogeneous and can be quite different from each other. For example, wastes on private vehicles usually contain the bulky goods, white goods and excess wastes that are not picked up by collection vehicles. The composition of the total waste stream is estimated from the proportion that each sub–waste stream contains.

When possible, vehicles entering the disposal facility from the survey area are weighed to establish the amount disposed. When weigh scales do not exist at the disposal facility, collection vehicles should pass by the nearest scales operated by the Ministry of Transportation and Highways. Vehicles are randomly chosen to contribute their waste to the survey.

Loads of wastes are taken for the survey either from waste collection vehicles or groups of private vehicles. Loads of waste selected for the survey are dumped away from other activity. To aid in the removal of large objects, loads are spread while being dumped. Large and readily identifiable objects are separated and weighed to get their percentage of each load.

Representative samples, about 136 kg (300 lb) in size, are taken from the remaining waste. Six or seven bags of waste about 20 kg each are grabbed from as many random locations of the pile. These bags of waste are weighed and are sorted into the desired categories on a sorting table. A detailed list of categories recommended for composition analysis is presented in Table 1.

Moisture contents of the sorted components are estimated by taking 100 – 500 gram samples to a lab for oven drying. The moisture content of the various waste categories changes depending on the degree of contamination and exposure to weather conditions during storage and collection. Moisture contents are useful information for comparing composition results of different loads or different sources.

This suggested methodology is unique in several ways. It recommends sorting the waste into detailed waste categories. It improves the reliability of the estimates by dealing separately with the various sub–waste streams which make up the total waste stream. The approach used is also unique in the way that large and bulky items are incorporated into the survey results. Finally, few other surveys consider the effects of moisture on weights and percentages.

VALIDATION OF METHODOLOGY

The goal in composition analysis is to provide an estimate of the percentage composition of each sorted category with some confidence in the estimate. Increasing the number of samples analyzed improves the confidence of the results. Composition analysis is labour intensive and getting samples can be costly and time consuming. Alternatively, results based on a small number of samples can misrepresent the waste stream being studied.

TABLE 1 DETAILED LIST OF CATEGORIES FOR COMPOSITION ANALYSIS

- PAPER
  - newspaper, including non–glossy magazines and flyers,
  - corrugated cardboard and brown paper bags,
  - fine/ledger paper, including bond and computer,
  - glossy magazines and fliers, telephone books, books
  - packing paper–food boxes and trays, tubes, containers, waxed paper, etc.,
  - tetra pak beverage containers,
  - non–packaging paper, including towels, napkins, and mail (n.e.c.),
  - other paper, including multi–material combinations such as bubble packs, meat soaks, carbon or blue print paper, and window envelopes, and
  - contaminated paper, including disposable diapers and sanitary napkins;

- GLASS
  - beverage containers, refundable,
  - beverage containers, non–refundable,
  - food and other containers,
  - other glass, including mirrors, plate, pyrex and multi–material combinations;

- METAL
  - aluminum beverage containers, refundable,
  - aluminum beverage containers, non–refundable,
  - other aluminum including foil, tins and cookwear,
  - steel beverage containers,
  - other steel cans,
  - other ferrous, including banding and machine parts,
  - non–ferrous (copper, brass, lead, etc.), and
  - other metal, including multi–material combinations;

- PLASTIC
  - Polyethylene terephthalate (PET) beverage containers, code 1*
  - other PET,
  - High Density Polyethylene (HDPE) – all colours, code 2*
  - Low Density Polyethylene (LDPE), code 4*
  - Polyvinyl Chloride (PVC), code 3*
  - Polystyrene (PS), code 6*
  - Polypropylene (PP), code 5*
  - other plastics, code 7*, Saran Wrap, acryl butyl styrene (ABS), and
  - multi–resin materials, such as laminates, and multi–material combinations;

- ORGANIC
  - kitchen and restaurant waste, according to animal or vegetable origin,
  - yard waste (grass, leaves, cuttings and stalks),
  - land clearing or landscaping debris, including brush, trees, large tree limbs and stumps,
  - other wood, including pallets, scrap lumber and boxes, and
  - food and agricultural processing waste;

- TEXTILE
  - natural fibre,
  - synthetic fibre;

- LEATHER
  - including foot wear with multi–material combinations;

- RUBBER
  - used tires,
  - other rubber products (including foam rubber);

- WHITE GOODS
  - including refrigerators, stoves, etc.;

- BULKY GOODS
  - including office and household furniture;

- BROWN GOODS
  - including electrical and electronic appliances and toys;

- CONSTUCTION, DEMOLITION GOODS
  - gyproc;
  - inerts including concrete, asphalt, bricks, rocks, and dirt;
  - insulation, preserved lumber, and other materials n.e.c.;

- RESIDUE
  - including ash, ceramics and fines;

- HAZARDOUS WASTES

- OTHER MATERIALS (n.e.c.)

(n.e.c.) = not elsewhere classified

* from the plastic industry's voluntary coding system

The number of samples to take depends on a trade off between the desired reliability of the results with the resources necessary to get and sort the samples.

In general, the number of samples necessary to get reliable estimates of some waste categories are less than for others. The waste categories that require the least number of samples are the major categories of: paper, glass, metals, plastics, organics, textiles and residue as well as some sub-categories: newspaper, cardboard, glossy magazines/telephone books, packaging and non-packaging paper, glass containers, steel cans, multi-material metals, rigid HDPE and LDPE film plastics, and organic kitchen wastes. The other waste categories need a greater number of samples for reliable estimates. In general, large and bulky items or those that are not as frequently found in the waste stream require a very large number of samples for reliable composition estimates. Large and bulky items are: white goods, bulky goods, construction/demolition wastes, wood, and landscaping wastes. Examples of items rarely found in the waste stream are leather, rubber, steel beverage cans, and non-ferrous metals.

The methodology of sampling, sorting, and analysis, as developed during the survey and described in the Procedural Manual (GLL, 1991a), turned out to yield reliable estimates of waste composition within the various waste streams studied. Statistical analysis revealed high levels of precision and generally low standard deviations of the means of most categories of waste for most waste streams studied.

The precisions of the composition estimates presented in this report were generally better than anticipated from results of other surveys (Klee and Carruth, 1970; Klee, 1980). One reason is the methodology used for incorporating large objects into the estimates. Previous studies consider only the sample that is sorted into the desired components (Britton, 1972). Some previous surveys reduce large objects mechanically and mixed them into the load before taking the sample for sorting (Musa and Ho, 1981). This survey separates and weighs the large objects to determine their percentages of the load. The composition of the load is then estimated by combining the percentages of the large objects with the composition of the sorted sample.

Another reason that precisions were better than expected is the size of the sample sorted. A 136 kg (300 lb) sample size was used in this study, rather than 91 kg (200 lbs) used in comparable studies (Klee, 1980). Composition estimates improve by increasing the size of the sample sorted (Lohani and Ko, 1988).

Survey results from private vehicles were less precise than those from collection vehicles. The mixing of waste that occurs on the collection vehicles en route is favourable since 136 kg samples are more representative of the waste stream. Therefore, when surveying wastes from private vehicles, a large number of vehicles need to be surveyed.

A minimum of six samples is recommended for future surveys of waste on collection vehicles.

WASTE COMPOSITION RESULTS

Testing of the methodology was carried out in four communities in B.C. The communities involved in composition analysis were:

1) Kamloops:
   - an urban area with separate collection of residential and ICI wastes with minimal source separation/recycling programs in place;
2) Maple Ridge:
   - an urban area with separate collections of residential and ICI waste, with a well established source separation/recycling program in place;
3) Castlegar:
   - a small community generating mostly residential wastes; and
4) Lower Slocan Valley:
   - rural residential waste from three electoral areas of the Regional District of Central Kootenay.

To perform the surveys of this report, Gartner Lee organized a survey team of an environmental engineer, a technician, and a sorting crew of four to five people. The survey team sampled and analyzed wastes during two, week long surveys for each municipality, one during the fall of 1990, and the other during the spring of 1991.

Figure 1 presents the average of the overall waste compositions for Maple Ridge, Kamloops and Castlegar/Slocan Valley based on wet weight percentages. Overall, the study revealed that by far the largest components of municipal solid waste (MSW) are paper and organics. About 32% of MSW consists of newspaper, packaging, cardboard, fine paper, magazines, and telephone books, with the first three being the largest parts of the paper component. About 32% consists of organics made up of kitchen wastes, yard wastes landscaping wastes and wood.

Glass, metals, and plastic each form about 5% to 7% of MSW. In the glass category, non-refundable bottles made up the largest component. In metals, steel cans and other ferrous items were the largest components. In the plastic category, LDPE film, HDPE film, and HDPE rigid plastic were the largest components.

Other components made up about 17% of MSW.

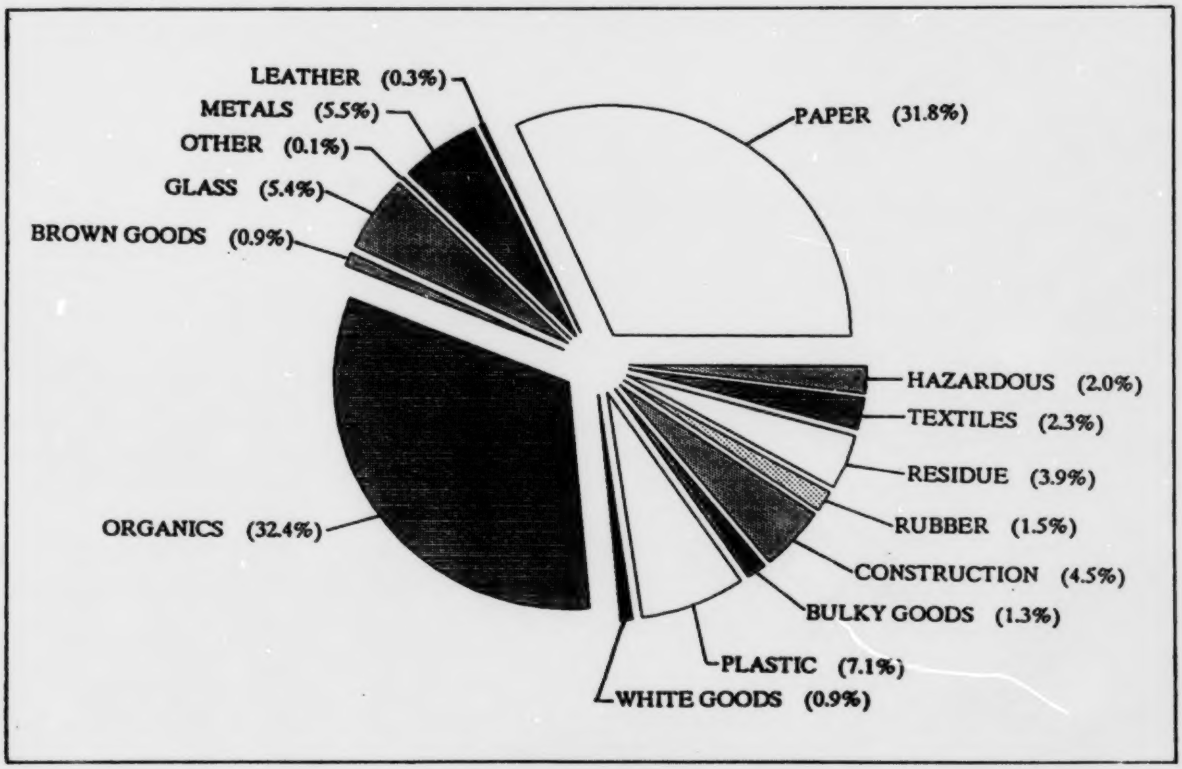

FIGURE 1 AVERAGE WASTE COMPOSITIONS FOR MAPLE RIDGE, KAMLOOPS, CASTLEGAR AND SLOCAN VALLEY

WASTE VARIABILITY

The composition of wastes vary depending on the community generating the waste, the differing waste sources (residential, ICI, urban or rural) and the season of waste generation.

Demographic

Table 2 presents the estimated waste compositions for Maple Ridge, Kamloops, and Castlegar/Slocan Valley. To estimate the overall MSW composition of each community, the waste stream was segregated into smaller, more homogeneous sub–waste streams. The sub–waste streams for Kamloops and Maple Ridge were: residential wastes on collection vehicles, residential wastes on private vehicles, ICI wastes on collection vehicles, ICI wastes on private vehicles, and other miscellaneous wastes. The sub–wastes streams for Castlegar and Slocan Valley were: combined residential and ICI wastes on collection vehicles, and wastes on private vehicles. The entire waste streams of each study area were not always included. Maple Ridge and Kamloops compositions do not include wastes from ICI private sources, and other irregular sources. These compositions are based on wet (as–received) weights, and are therefore influenced by weather conditions and cross–contamination of the various waste categories.

When considering these composition results, one should understand that these are presented on a percentage basis. When weights are converted into percentages, each waste category becomes dependant on the other categories. For example, the large percentage of landscaping wastes in Kamloops' waste reduces the percentages of the other categories.

Analysis of proportions of waste components in a town with a well–established and generally supported recycling program (Maple Ridge), and in a town with few opportunities and little encouragement for recycling (Kamloops), revealed surprisingly little difference between waste proportions in the two communities.

Waste Sources

Table 3 summarizes the compositions of wastes on collection vehicles servicing Maple Ridge, Kamloops, Castlegar and Slocan Valley. This table was compiled to demonstrate waste variability caused by different waste sources. The compositions presented are the average values of the fall and spring survey results.

Many factors affect the wastes collected. Collection vehicles typically collect curbside wastes (mainly residential) and wastes stored in bins (ICI and apartments) either separately or combined. In Maple Ridge and Kamloops, residential curbside wastes are collected separately from wastes stored in bins. In Castlegar, all wastes are collected in one vehicle. Slocan Valley wastes included ICI wastes, although these were a very small fraction of the total.

Wastes on collection vehicles do not represent the entire waste stream. White and bulky goods, yard and landscaping wastes enter the disposal site on private vehicles.

Residential and ICI

Residential loads and ICI loads contained similar proportions of paper, but the make–up of that paper varied. In ICI loads, the largest component was cardboard. Newspaper, non–packaging (towels, napkins, and mail), and packaging also made up large parts of ICI paper waste. In residential paper waste, newspaper was the largest component, followed by packaging. Contaminated paper (disposable diapers and sanitary pads) was a large part of the residential paper component, as were magazines, telephone books, and cardboard.

Organic waste formed a slightly larger proportion of residential waste than of ICI. Vegetable wastes from the kitchen made up the largest proportion of organic waste in both residential and ICI waste. In ICI waste, the second largest percentage was wood waste. In residential waste, kitchen wastes of animal origin and yard waste have the next largest percentages.

TABLE 2 OVERALL WASTE COMPOSITIONS FOR MAPLE RIDGE, KAMLOOPS, AND CASTLEGAR/SLOCAN VALLEY

COMPONENTS	MAPLE RIDGE	KAMLOOPS	CASTLEGAR SLOCAN VALLEY
Paper (total)	**33.0%**	**28.9%**	**33.4%**
newspaper	7.4%	6.3%	5.6%
cardboard	7.8%	4.8%	8.4%
fine	2.1%	2.8%	2.7%
glossy / telephone	2.8%	2.8%	3.6%
packaging	4.3%	4.4%	4.4%
tetra brik	0.3%	0.4%	0.4%
non−packaging	3.7%	3.7%	4.0%
other / multi−material	1.3%	1.4%	1.2%
contaminated	3.3%	2.5%	3.1%
Glass (total)	**5.0%**	**4.8%**	**6.4%**
beverage – refundable	0.7%	0.5%	0.6%
beverage – nonrefundable	2.1%	2.0%	2.4%
food	1.7%	1.2%	1.9%
other	0.6%	1.0%	0.8%
Metals (total)	**5.3%**	**5.0%**	**6.2%**
alum. bev. – refundable	0.2%	0.2%	0.1%
alum. bev. – nonrefundable	0.0%	0.0%	0.0%
other aluminum	0.6%	0.4%	0.5%
steel beverage	0.0%	0.0%	0.0%
other steel cans	1.9%	1.7%	2.6%
other ferrous	1.6%	2.0%	2.3%
non−ferrous	0.0%	0.1%	0.0%
other / multi−material	0.9%	0.6%	0.7%
Plastic (total)	**8.2%**	**6.0%**	**7.3%**
PET beverage (1)	0.1%	0.1%	0.1%
other PET	0.1%	0.1%	0.0%
HDPE (2) rigid	1.1%	0.9%	1.0%
LDPE (4) rigid	0.2%	0.1%	0.1%
HDPE (2) film	1.3%	2.0%	2.3%
LDPE (4) film	2.7%	1.1%	1.4%
PVC (3)	0.2%	0.1%	0.1%
PS (6)	0.8%	0.7%	0.7%
PP (5)	0.6%	0.3%	0.3%
other plastics (7)	0.2%	0.1%	0.3%
multi−resin / material	0.9%	0.5%	0.7%
Leather	**0.4%**	**0.2%**	**0.4%**
Rubber (total)	**1.1%**	**1.9%**	**1.3%**
used tires	0.5%	1.7%	1.1%
other	0.7%	0.3%	0.3%
Organic (total)	**30.9%**	**37.4%**	**28.8%**
kitchen – animal	3.0%	2.8%	3.0%
kitchen – vegetable	12.7%	12.9%	15.9%
yard waste	6.7%	4.2%	2.6%
landscaping	4.9%	13.6%	3.0%
wood	3.5%	4.0%	4.1%
Textiles (total)	**2.8%**	**2.1%**	**1.9%**
natural	0.9%	0.4%	0.5%
synthetic	1.9%	1.7%	1.4%
Brown goods	**0.4%**	**1.0%**	**1.4%**
Bulky goods	**2.0%**	**0.8%**	**1.1%**
White goods	**0.0%**	**1.8%**	**0.8%**
Construction, Demolition	**4.5%**	**4.2%**	**4.9%**
Residue	**3.6%**	**4.2%**	**3.9%**
Hazardous	**2.6%**	**1.5%**	**1.7%**
Other	**0.1%**	**0.1%**	**0.3%**

TABLE 3 SUMMARY OF COMPOSITIONS OF WASTES ON COLLECTION VEHICLES

COMPONENTS	RESIDENTIAL		ICI		RESIDENTIAL AND ICI	
	Maple Ridge	Kamloops	Maple Ridge	Kamloops	Castlegar	Slocan
Paper (total)	**37.9%**	**36.4%**	**42.8%**	**40.1%**	**42.6%**	**36.9%**
newspaper	8.7%	10.2%	9.1%	6.5%	7.7%	5.1%
cardboard	4.5%	3.8%	13.3%	8.8%	10.6%	7.6%
fine	2.2%	2.4%	3.0%	4.9%	3.5%	3.2%
glossy / telephone	3.8%	4.1%	2.5%	3.2%	4.4%	4.6%
packaging	6.3%	6.3%	5.1%	5.3%	5.5%	5.4%
tetra brik	0.6%	0.3%	0.2%	0.7%	0.5%	0.4%
non–packaging	4.6%	3.6%	4.6%	6.2%	5.3%	4.8%
other / multi–material	1.4%	1.6%	1.8%	2.1%	1.6%	1.2%
contaminated	5.8%	4.2%	3.4%	2.4%	3.4%	4.6%
Glass (total)	**6.4%**	**5.6%**	**4.0%**	**6.8%**	**5.6%**	**8.0%**
beverage – refundable	0.9%	0.4%	0.4%	0.9%	0.7%	0.9%
beverage – nonrefundable	2.6%	2.7%	1.7%	2.7%	2.2%	4.2%
food	2.4%	2.1%	1.3%	1.1%	1.7%	2.3%
other	0.5%	0.5%	0.6%	2.1%	0.9%	0.6%
Metals (total)	**6.0%**	**5.5%**	**6.1%**	**6.6%**	**5.9%**	**6.5%**
alum. bev. – refundable	0.2%	0.1%	0.2%	0.3%	0.2%	0.1%
alum. bev. – nonrefundable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
other aluminum	0.7%	0.6%	0.7%	0.5%	0.4%	0.4%
steel beverage	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
other steel cans	3.1%	3.0%	1.9%	1.4%	3.1%	3.5%
other ferrous	0.9%	0.9%	2.0%	3.6%	1.4%	1.2%
non–ferrous	0.0%	0.1%	0.0%	0.1%	0.0%	0.2%
other / multi–material	1.0%	0.7%	1.2%	0.6%	0.7%	1.0%
Plastic (total)	**8.8%**	**8.0%**	**10.6%**	**7.5%**	**8.8%**	**8.5%**
PET beverage (1)	0.1%	0.0%	0.1%	0.1%	0.2%	0.1%
other PET	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
HDPE (2) rigid	1.1%	1.3%	1.5%	0.9%	1.2%	1.5%
LDPE (4) rigid	0.3%	0.2%	0.3%	0.2%	0.1%	0.2%
HDPE (2) film	1.3%	2.9%	1.1%	2.5%	3.2%	2.9%
LDPE (4) film	3.5%	1.5%	4.0%	1.4%	1.5%	1.6%
PVC (3)	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%
PS (6)	0.9%	0.8%	1.0%	1.0%	1.0%	0.7%
PP (5)	0.5%	0.4%	1.0%	0.3%	0.3%	0.5%
other plastics (7)	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%
multi–resin / material	0.9%	0.6%	1.2%	0.6%	0.7%	0.7%
Leather	**0.5%**	**0.4%**	**0.4%**	**0.2%**	**0.1%**	**0.6%**
Rubber (total)	**0.3%**	**0.3%**	**1.0%**	**3.1%**	**0.3%**	**0.3%**
used tires	0.0%	0.0%	0.2%	2.8%	0.0%	0.0%
other	0.3%	0.3%	0.7%	0.3%	0.3%	0.3%
Organic (total)	**28.4%**	**32.6%**	**21.5%**	**23.5%**	**26.0%**	**27.8%**
kitchen – animal	4.0%	5.1%	2.5%	2.1%	3.4%	3.3%
kitchen – vegetable	17.4%	18.3%	12.8%	15.7%	18.2%	22.4%
yard waste	5.8%	8.2%	2.9%	1.6%	2.2%	0.8%
landscaping	0.2%	0.2%	0.2%	0.7%	0.0%	0.1%
wood	1.0%	0.8%	3.1%	3.3%	2.1%	1.2%
Textiles (total)	**2.8%**	**3.0%**	**3.4%**	**2.4%**	**1.8%**	**3.1%**
natural	0.9%	0.7%	1.5%	0.5%	0.6%	0.7%
synthetic	1.9%	2.3%	1.9%	1.9%	1.3%	2.3%
Brown goods	**0.6%**	**0.7%**	**0.4%**	**1.5%**	**0.8%**	**0.7%**
Bulky goods	**0.5%**	**0.3%**	**1.6%**	**0.7%**	**0.3%**	**0.3%**
Construction, Demolition	**1.3%**	**0.5%**	**0.4%**	**2.5%**	**1.7%**	**1.1%**
Residue	**4.1%**	**4.9%**	**4.5%**	**3.4%**	**4.1%**	**4.4%**
Hazardous	**2.3%**	**1.7%**	**3.1%**	**1.6%**	**1.8%**	**1.5%**
Other	**0.0%**	**0.2%**	**0.1%**	**0.0%**	**0.0%**	**0.4%**

The remaining components of MSW make up similar proportions of both ICI and residential waste. There was a significantly higher proportion of glass food jars and steel cans in residential loads. Rubber was found more commonly in ICI waste.

Urban and Rural

The comparison between urban and rural waste streams showed that more paper is thrown out in urban areas. Slightly more glass, in particular non–refundable beverage glass, find their way into rural waste.

Seasonal

One goal of performing the survey twice at each site was to capture some seasonal variation in the waste stream. Therefore, survey results from the fall were compared with those from the spring. For example, Table 4 presents the average compositions of Kamloops' residential wastes on collection vehicles for both the fall and spring surveys.

Statistical comparison of compositions show that the percentages of corrugated cardboard, total organics due to yard wastes, and natural textiles are higher in the fall survey than in the spring survey. Percentages of fine paper, glass food containers, other glass, total metals due to the steel cans and multi–material metals, and multi–resin/material plastics are significantly higher in the spring survey.

The fall and spring waste streams of Maple Ridge, Castlegar and Slocan Valley were all compared (GLL, 1991b). Each comparison had differences of different waste categories. These comparisons emphasis the changing nature of waste composition.

MOISTURE CONTENTS OF WASTE CATEGORIES

Knowledge of the moisture contents of the components in a composition analysis is valuable information. In this report, moisture contents are used to convert wet (as–received) weights into dry weights. Dry weights percent compositions are used to compare the percent compositions from different samples. The reason for taking samples from different demographic areas is to identify differences. If wet weights are not converted to dry weights, uncertainty about the variability of the moisture in the weights handicaps the analysis. Dry weight is the weight of material when it has all of its moisture removed.

The moisture contents of the various waste categories are also useful when estimating the weights of recyclable materials present in the waste. Presumably paper products are less contaminated when entering a recycling program than when entering a disposal site. Glass jars and metal cans are often cleaned. Using moisture contents of the waste entering the disposal site with expected moisture contents of wastes separated for recycling, the estimated weights of recyclable materials in the waste stream can be better estimated.

Moisture contents can also be used to determine the energy needed to drive off the moisture from the waste before combustion will occur if incineration is considered as a disposal option. It is also important for proper control of composting or digestion of the waste.

Waste compositions based on wet and dry weights vary considerably. For example, Table 5 compares percent composition figures from wastes on residential collection vehicles in Kamloops using "wet" and "dry" weight data.

This comparison shows the importance of making clear the moistures contained in the weights upon which percent composition is reported. Table 5 shows that by drying all categories to a consistent dry standard, percent composition by weight for some waste categories changes substantially. For example, the percent composition by weight of organics dropped by over 10% and the relative percentage of many categories, notably paper, glass and metals, increased to make up the difference.

TABLE 4 COMPARISON OF FALL AND SPRING COMPOSITIONS (KAMLOOPS RESIDENTIAL WASTES)

COMPONENTS	PERCENT COMPOSITION	
	FALL SURVEY	SPRING SURVEY
Paper (total)	**33.2%**	**39.6%**
newspaper	9.5%	10.8%
cardboard	4.4%	3.2%
fine	1.8%	3.0%
glossy / telephone	3.0%	5.1%
packaging	5.8%	6.8%
tetra brik	0.3%	0.3%
non-packaging	3.8%	3.5%
other / multi-material	1.1%	2.0%
contaminated	3.5%	4.9%
Glass (total)	**5.1%**	**6.1%**
beverage – refundable	0.5%	0.3%
beverage – nonrefundable	2.6%	2.7%
food	1.7%	2.5%
other	0.2%	0.7%
Metals (total)	**4.8%**	**6.2%**
alum. bev. – refundable	0.2%	0.1%
alum. bev. – nonrefundable	0.0%	0.0%
other aluminum	0.5%	0.7%
steel beverage	0.1%	0.0%
other steel cans	2.5%	3.5%
other ferrous	0.9%	0.8%
non-ferrous	0.1%	0.0%
other / multi-material	0.5%	0.9%
Plastic (total)	**7.4%**	**8.5%**
PET beverage (1)	0.0%	0.1%
other PET	0.1%	0.1%
HDPE (2) rigid	1.0%	1.5%
LDPE (4) rigid	0.1%	0.2%
HDPE (2) film	4.3%	1.4%
LDPE (4) film		3.0%
PVC (3)	0.1%	0.1%
PS (6)	0.8%	0.8%
PP (5)	0.4%	0.4%
other plastics (7)	0.1%	0.3%
multi-resin / material	0.4%	0.8%
Leather	**0.4%**	**0.4%**
Rubber (total)	**0.3%**	**0.4%**
used tires	0.0%	0.0%
other	0.3%	0.3%
Organic (total)	**37.4%**	**27.8%**
kitchen – animal	4.9%	5.4%
kitchen – vegetable	17.9%	18.7%
yard waste	13.5%	2.8%
landscaping	0.3%	0.2%
wood	0.8%	0.7%
Textiles (total)	**3.1%**	**2.8%**
natural	0.9%	0.4%
synthetic	2.1%	2.5%
Brown goods	**0.7%**	**0.7%**
Bulky goods	**0.3%**	**0.4%**
Construction, Demolition	**0.4%**	**0.7%**
Residue	**4.9%**	**4.8%**
Household Hazardous	**1.7%**	**1.7%**
Other	**0.3%**	**0.0%**

TABLE 5 COMPARISON OF PERCENT COMPOSITIONS USING "WET" AND "DRY" WEIGHTS (KAMLOOPS RESIDENTIAL WASTES)

Category	Average % Composition Using Wet Weights	Average % Composition Using Dry Weights
Paper	36.4	39.7
Glass	5.6	8.2
Metals	5.5	7.3
Plastic	8.0	9.0
Leather	0.4	0.6
Rubber	0.3	0.5
Organic	32.5	21.8
Textiles	3.0	3.7
Brown Goods	0.7	0.9
Bulky Goods	0.3	0.4
Construction	0.5	0.7
Household Hazardous	1.7	2.6
Residue	4.9	4.4
Other	0.2	0.2

The components of the waste are contaminated by each other during the disposal and collection process. Moisture contents can be altered considerably depending on the type of collection, the time between collections and weather conditions en route. Wastes from different seasons or demographics can have considerably different moisture contents.

Table 6 shows the average moisture contents of various waste components. Items most susceptible to variation in moisture content from contamination are paper products, plastics, some metals, and textiles. The moisture contents of contaminated papers (i.e., diaper and sanitary pads) vary considerably due to the nature of their contamination. Tetrapaks, aluminum beverage containers, other aluminum, hard and film plastics and polystyrene all have highly variable moisture values since the weight of contamination can be significant compared to their own weights. Multi–material metals and plastics have high and variable moisture values depending on the amount of paper involved.

The total moisture content of MSW generated in B.C. is estimated to be 30.3%.

CONCLUSIONS

Knowledge of waste composition enables municipalities to develop new management strategies to reduce, reuse and recycle, as well as to manage residuals. This paper describes a straightforward way to survey the waste being discarded at transfer stations or landfills. It provides reliable estimates of waste composition by combining survey results of both the large items in waste loads with the detailed analysis of smaller samples of each load. This waste survey can be undertaken by municipalities at relatively low costs compared to the savings which might be made by reducing disposal costs. Results of surveys in four communities in British Columbia demonstrate the variable nature of waste. To fully commit to waste reduction requires that waste composition surveys be performed in different municipalities and on a continued basis.

TABLE 6 MOISTURE CONTENTS OF WASTE CATEGORIES

Category	Moisture Content (%)
Paper	
newspaper	30.6
cardboard	32.5
fine	21.8
glossy / telephone	16.6
packaging	27.5
tetra brik	18.2
non-packaging	39.1
other / multi-material	25.0
contaminated	27.0
Glass	
beverage	1.8
food / container	4.0
Metals	
aluminum beverage	11.1
aluminum other	22.0
steel cans	8.4
other / multi-material	17.4
Plastic	
hard	11.9
film	25.4
PS	18.8
multi-resin / multi-material	16.1
Organic	
kitchen animal	38.3
kitchen vegetable	59.8
yard waste	56.1
Textiles	20.2
Residue	35.1
Total	30.3

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ESTIMATING THE COMPOSITION OF NON-HAZARDOUS SOLID WASTE PRODUCED BY ICI (INDUSTRIAL/COMMERCIAL/INSTITUTIONAL) SOURCES IN ONTARIO —

A FIRST STEP TO DEVELOPING A WASTE DIVERSION PROGRAM

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1. *BACKGROUND*

The costs for disposal of non-hazardous solid waste have increased dramatically in the last few years. In the Toronto area tipping fees have increased from $20/tonne five years ago to $150/tonne in 1991. This has changed attitudes to solid waste generation and disposal dramatically. Industries and commercial establishments are looking on a case-by-case basis at how waste generation and disposal costs can be reduced. Municipalities are looking at methods for diverting waste away from landfill. The government of Ontario is looking at methods by which the diversion targets of 25% away from landfill by 1992, and 50% by the year 2000 can be achieved.

Whereas many studies have been carried out on the composition of household garbage, until recently, comparatively little was known about the composition of garbage from ICI (Industrial/Commercial/Institutional) sources. As this makes up an estimated 60% of the waste disposed in landfills in Ontario, information on the composition of this stream became critical to formulating waste diversion strategies for the Province of Ontario.

2. *OBJECTIVES*

The objective of the study was to estimate, to the extent possible with existing data, the quantity and composition of non-hazardous non-registrable waste generated and disposed by ICI sources in Ontario.

To be of maximum benefit to subsequent studies, the data generated on ICI waste had to include the following factors:

- ICI generation by waste type
- ICI generation by industry (IMC) type
- ICI generation by county

It was determined that the best way to generate these estimates was to set up a model which took all of these factors into account.

The categories of waste of particular interest were those which could be diverted away from landfill and incineration (i.e. paper, cardboard, wood, compostable organics, metal etc.) and potentially reused or recycled.

3. *MATERIAL EXCLUDED FROM ESTIMATES*

Several large volume ICI residuals were not specifically considered in the study. These included solid wastes from:

- construction/demolition not disposed in public landfills
- decommissioning and clean-up of spills and contaminated soils
- road construction and maintenance
- dredging of waterbodies

The following materials were also excluded:

- foundry sand
- blast furnace slag
- fly ash
- bottom ash
- compost
- sewage sludge

4. *DESCRIPTION OF STUDY DATABASE*

4.1 ICI Categories Used

It was determined that in order to meet the needs of concurrent economic studies, the estimation method would incorporate the economic sectors developed by ERL (Econometric Research Limited). The ERL model involves 25 sectors, known as Input Matrix Categories (IMCs), covering all SIC groups, as shown in Table 1.

4.2 ICI Waste Composition Data Used

ICI waste composition data from surveying and auditing activities at 180 companies in the Essex-Windsor area, was used as the primary information source in the study. This was supplemented where necessary (i.e. where less than five data sets were available for a particular IMC) by data obtained from the City of Cornwall and in some cases from studies carried out in Seattle, Washington, and Brattleboro, Vermont. Data on employment and quantities of various waste components produced by each company were entered in the appropriate IMC waste composition file. IMC-specific average waste compositions and per employee generation rates were calculated from the data available. The results of this exercise are presented in Table 2.

Several points regarding these data are worth noting. Data from four studies contributed to the IMC-specific data. This limits the coverage of some geographical and economic areas of the province. For example, data on IMC 2, Mining, were unavailable since the available survey data did not cover Northern Ontario. (In the case of IMC 2, Mining, this was not considered a serious limitation as the process itself does not generate quantities of material which are disposed at municipal landfills.)

For each IMC, the total amount of waste reported by all companies in the database was divided by the total number of employees reported for all the companies in the database to estimate an average per employee generation rate for the IMC. In some IMCs, data on a few firms appeared out of line with the remaining data. In many of these cases, some explanation could be found relating to the activities of the firm, and such outliers were deleted using professional judgement.

It should also be noted that while composition and generation rates for most IMCs were based on data from at least five firms, those firms did not necessarily represent the full range of activity in that sector. For example, data on IMC 1, Agriculture, are concentrated on greenhouses, rather than on farming or forestry activities. However, these data were the most comprehensive available at the time of the study.

4.3 ICI Waste Categories Used

The waste categories used in the study database were the same as the categories used by Essex-Windsor, from whom much of the study data were obtained. These were:

- OCC
- Fine paper
- Other paper
- Wood
- Glass
- Plastic
- Organics
- Metal
- Tires
- Garbage
- Other

Quantities of unsorted garbage (ie, waste components not identified) made up a large part of the data. This "garbage" quantity was redistributed in the various categories in proportion to the reported composition of the sorted waste stream.

The category "other" was retained in the database as reported. The form of the raw data suggested that quantities in the "other" category were actually segregated, potentially recyclable items and not just "garbage". It was felt that this information, though limited, should not be discarded.

5. *ICI WASTE QUANTITY ESTIMATES*

Once per employee generation rates were developed for each IMC, data on employment could be used to estimate total ICI waste produced in the Province of Ontario. This was accomplished using confidential provincial and county employment data, along with employee waste generation rates estimated by the study database, to estimate ICI waste quantity production. The ICI estimate took place through a series of steps, described below.

The calculation was first performed on the provincial level in order to ascertain whether the method yielded reasonable figures. A number of iterations were required to arrive at a reasonable provincial total quantity. When a reasonable provincial total was established, estimation of ICI waste generation at the county level took place. This permitted the comparison of estimates generated by the study database to available actual data.

In some cases, county-specific information on industrial sectors was used to adjust employee generation rates. For example, data on the construction sector in Metro Toronto was used to adjust generation rates for IMC 20.

Once the total ICI waste generation figure for each county was finalized (using either model or Waste Management Master Plan (WMMP) data), the Provincial total ICI waste quantity, and total quantities of material in each of the waste categories, were re-calculated. For some waste quantities (specifically OCC, organics and tires), the calculated totals were adjusted using reported data from other sources. As an example, the ICI waste model calculated a total OCC value which was greater than the estimated quantity of OCC used in Ontario in 1989, as reported by the pulp and paper industry. In this case, the study model values for generation by IMC group were adjusted to reflect the estimated Provincial OCC generation of 441,000 tonnes.

A similar exercise was carried out for organics and used tires. The total quantity of organic waste produced by the ICI sector was estimated at 600,000 tonnes, based on data from a study of municipal solid waste generation in Seattle, Washington. The total quantity of used tries generated by the ICI sector was obtained from a study by Pilorusso. Waste generation rates and waste composition for each IMC were adjusted accordingly.

6. *RESULTS*

The method described above yielded an estimate of about 5,361,000 tonnes of ICI waste produced in the Province in 1989.

Table 3 presents the estimated breakdown of this total by waste type. The table shows that major waste categories were wood (2.2 million tonnes), paper (700,000 tonnes), and organics and metal at approximately 600,000 tonnes each. Table 4 shows the estimated total amount of waste generated by each ICI sector. This table shows that the major contributing sectors for wastes considered in this study are:

- construction
- communications and services
- food and beverage, and
- retail

It should be noted that the Communications and Service industry, defined in this study as IMC 22, includes a large number of SIC groups, as shown in Table 1

7. *APPLICABILITY OF STUDY MODEL TO WASTE DIVERSION PROGRAMS*

This is the first effort made to quantify and characterize non-hazardous waste produced by the ICI sector in Ontario, and is a valuable first step in tackling a serious waste management problem. The above estimates can be refined as more data become available on ICI waste composition. In the interim, the waste composition estimates developed by the model are valuable for planning waste diversion programs. The methodology developed in this study can be applied to any community of any size, as long as employment data by general ICI category are known. The advantage of this system is that preliminary planning of waste diversion activities can be carried out without the delay and expense associated with designing and implementing waste composition studies.

TABLE 1

AGGREGATION OF INDUSTRIAL/COMMERCIAL/INSTITUTIONAL ESTABLISHMENTS INTO 25 INPUT MATRIX CATEGORIES FOR WASTE COMPOSITION ESTIMATES

Input Matrix Category (IMC) Number	Description		Canadian 2 Digit Major SIC Categories Included
1.	Agriculture:	agriculture	01, 02
		forestry	04, 05
		fishing, hunting and trapping	03
2.	Mining:	metal mines	06
		mineral fuels	07
		non-metal mines	08
		services incidental to mining	09
3.	Food and Beverage Industries		10, 11
4.	Rubber, Plastic and Leather Industries		15-17
5.	Textile, Knitting Mills and Clothing Industries		18, 19, 24
6.	Wood Industries		25
7.	Furniture and Fixtures Industries		26
8.	Paper and Allied Industries		27
9.	Printing and Publishing Industries		28
10.	Primary Metal Industries		29
11.	Metal Fabricating Industries		30
12.	Machinery Industries		31
13.	Transportation Industries		32
14.	Electrical Products Industries		33
15.	Non-metallic Mineral Products Industries		35

TABLE 1 (cont'd)

Input Matrix Category (IMC) Number	Description	Canadian 2 Digit Major SIC Categories Included
16.	Chemical and Chemical Products Industries	37
17.	Miscellaneous Manufacturing Industries	39
18.	Other Major Manufacturing Industries:	
	tobacco products industries	12
	petroleum and coal products industries	36
19.	Wholesale Trade Margins	50-59
20.	Construction	40-44
21.	Transportation Margins	45-47
22.	Communications and Services:	
	communications	48
	owner occupied dwellings	
	finance, ins., and real estate	70-76
	education and health services	85, 86
	services to business management	77
	personal and misc. services	97
	amusement and recreation services	96
	accommodation and food services	91, 92
23.	Electrical Power and Gas	49
24.	Retail Trade Margins	60-65, 69
25.	* Other Sources:	
	operating office, lab, and food	81-84
	travel, promotion and advertising	98-99

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* IMC 25 contains SICs not accounted for in other IMCs, namely:

SIC 81 - Federal Government Service Industries
SIC 82 - Provincial and Territorial Government Industries
SIC 83 - Local Government Service Industries
SIC 84 - International and Other Extraterritorial Government Service Industries
SIC 98 - Member Organization Industries
SIC 99 - Other Service Industries

TABLE 2

SUMMARY OF AVAILABLE INFORMATION ON WASTE COMPOSITION PERCENTAGE AND GENERATION RATES BY INDUSTRIAL SECTORS IN ONTARIO (1)

											Generation Rates (kg/emp/day)		
IMC Category	OCC	Office Paper	Other Paper	Wood	Glass	Plastic	Organics	Metal	Tires	Other	Median	Average	Modified Median (2)
1	32.3	0.9	11.5	47.2	0	0	0	0	0	9.0	2.74	13.25	1.63
2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
3	4.4	0.8	3.7	2.0	8.6	2.0	60.6	5.1	0	12.8	11.96	15.41	14.98
4	9.6	0.7	1.4	18.1	0	18.8	0	5.8	31.4	14.3	4	7.22	7.15
5	1.0	0.4	18.1	1.7	0	8.8	0	1.3	0	68.8	1.62	1.69	1.66
6	3.5	0	0	65.8	0.1	5.7	0	1.5	0	23.4	4.48	4.72	4.4
7	6.7	0.8	0	15.2	0	0	0	6.0	0	71.3	2.51	9.63	8.45
8	6.5	13.2	0	39	0	0.2	13.4	20.8	0	6.8	5.25	5.50	5.13
9	1.8	5.1	81.8	2.7	0	0.2	0	0.2	0	8.2	1.19	2.02	1.95
10	5.6	0.1	17.3	52.0	0	0	0	1.6	0	23.4	2.86	15.07	5.84
11	4.6	0.1	11.5	11.7	0	1.1	0	48.5	0	22.5	2.83	6.52	5.94
12	5.4	0.2	1.3	11.4	0	3.5	2.7	23.9	0	51.6	1.37	3.53	3.21
13	4.7	0.5	1.4	12.0	0.4	0	0.2	29.3	0	51.4	2.35	6.53	5.95
14	12.3	2.6	33.2	38.8	0	4.1	0	7.5	0	1.5	4.48	3.97	3.16
15	1.7	4.0	0	3.5	0	0	0	65.4	0	25.4	6.83	7.74	7.47
16	47.7	1.6	11.4	1.4	3.0	8.9	0.2	5.0	0	20.7	3.90	6.57	3.29
17	18.5	0.7	31.4	6.5	1.2	0.8	0	21.0	0	19.8	1.64	1.33	0.96
18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
19	49.7	0	4.4	32.4	0	13.5	0	0	0	0	2.25	4.03	1.62
20	1.8	1.0	0	44.7	0	0.5	1.9	9.0	0	41.1	(b)	29.86	29
21	9.2	85.0	0	5.8	0	0	0	0	0	0	2.08	2.08	1.72
22	9.0	12.9	19.8	5.9	20.8	4.2	7.1	10.4	0.1	10.0	2.11	2.65	2.3
23	13.6	40.5	0	0	0	0	0	5.9	0	40.0	1.67	2.02	1.6
24	17.5	30.1	1.5	8.8	0.2	9.0	0.4	4.8	9.4	5.3	2.68	2.58	3
25	4.6	13.7	35.4	1.8	0.2	9.0	0.4	17.6	0	17.4	0.60	1.19	1.09

(1) These compositions and generation rates were developed from raw provided by studies in Essex-Windsor, Cornwall, Seattngton, and Brattleborn Vermot.
(2) Modified median is the value used in the database when outliers were deleted from available data

TABLE 3

ESTIMATED ICI WASTE QUANTITIES GENERATED IN ONTARIO IN 1989 BY WASTE COMPONENT

Component	**Quantity (tonnes)**
OCC	441,000
Office Paper	354,000
Other Paper	426,000
Wood	1,130,000
Glass	282,000
Plastic	163,000
Organics	600,000
Metal	599,000
Tires	88,000
Other	1,278,000
Total	**5,361,000**

TABLE 4

ESTIMATED ICI WASTE QUANTITIES GENERATED IN ONTARIO IN 1989 BY IMC CATEGORY

IMC Description	IMC Category Number	Estimated Waste Generated (tonnes) 1989
Agriculture	1	75,000
Mining	2	nd
Food & Beverage	3	468,000
Rubber, Plastic and Leather	4	135,000
Textile, Knitting and Clothing	5	38,000
Wood	6	25,000
Furniture and Fixtures	7	74,000
Paper and Allied Ind.	8	80,000
Printing and Publishing	9	42,000
Primary Metals	10	139,000
Metal Fabricating	11	171,000
Mechinery	12	49,000
Transportation	13	255,000
Electrical Products	14	81,000
Non Metallic Mineral Products	15	59,000
Chemical	16	61,000
Misc. Manufacturing	17	34,000
Other Major Manufactures	18	nd
Wholesale	19	166,000
Construction	20	1,601,000
Transportation	21	134,000
Communications and Services	22	1,155,000
Electrical Power and Gas	23	28,000
Retail Trade Margins	24	397,000
Other	25	94,000
TOTAL		**5,361,000**

Notes:

1. "nd" indicates no data available
2. Estimates of ICI waste quantities by IMC were developed by ERL Ltd. by multiplying the generation rates of Table 2 by employment in each IMC
3. Totals are rounded to the nearest 1,000 tonnes

NATIONAL PACKAGING PROTOCOL:
A COMPONENT OF A NATIONAL WASTE REDUCTION STRATEGY:

R.J. Squires
Office of Waste Management
Environment Canada

Background

The management of waste in Canada is indeed a significant problem and one that requires immediate attention. Most recent statistics indicate that Canadians generate 30 to 35 million tons of waste per year, of which about 16 million tons are from household and commercial sources. In 1989, Canada produced more waste than any other country in the world; 1.7 kilograms per person per day. Overall, Canadians spend over $1.5 billion per year on waste management activities.

The consumption of packaging in Canada is approximately one ton per family per year. It is estimated that 6.6 million tonnes of packaging were used in Canada in 1988. Of this total, some 5.7 million tonnes were disposed of by landfill and incineration, at an estimated cost in excess of $100 million.

The Canadian Packaging Industry

Packaging serves many useful and important functions in our consumer oriented society. Most notably, it is used to contain, transport, protect and market goods, as well as to provide product information to the consumer. It is commonly composed of one, or a combination of, six basic material types including; paper or paper products, plastics, wood, glass, steel and aluminum. Some typical examples of packages include pallets, boxes, bottles, cans, jugs, drums, wrappers, etc.

The packaging industry is a major contributor to the Canadian economy. More than 52,000 persons are employed in the Canadian packaging industry. The total value of packaging produced in Canada in 1988 was over $7 billion.

The Protocol Development Process

In May, 1989, the Canadian Council of Ministers of the Environment (CCME), recognized the seriousness of the waste management problem in Canada, and embarked on a process to address this increasingly significant environmental issue. The packaging component of the municipal solid waste stream is estimated to be approximately 30%. Packaging waste is also considered to be the major component of litter and is therefore "perceived" to be a much larger percentage of the waste problem. Consequently, reducing the amount of packaging waste was felt to be a logical first step towards addressing Canada's "Waste Crisis". Therefore, the CCME commissioned a National Task Force on Packaging to;

"Develop a National Packaging Policy for Canada within the broad review of solid waste management opportunities, including government purchasing and recycling policies".

In the development of Canada's National Task Force on Packaging, it was felt that representatives from all of the "stakeholders" in this issue should have an opportunity to input into the process. Consequently, membership was solicited from municipal, provincial and federal governments, the manufacturing, shipping and retail sectors of industry, and environmental and consumer organizations. In addition, six regional meetings were held across Canada, to provide an opportunity for the general public, and other organizations not represented on the Task Force, to contribute.

Task Force members were particularly prompted by public demand for packaging which is sensitive to the environment and consistent with "Sustainable Development" (i.e., which is compatible with waste reduction and with the wise use of energy, water and other resources). The Task Force was also aware of the fragmented approach to packaging waste reduction in the United States, and other countries, which has led to undesirable economic consequences for industry and ultimately, for the consumer.

The Task Force agreed that the Protocol would concentrate on industrial, household and commercial packaging. The Task Force focused on the management of packaging waste through a hierarchy of source reduction, reuse and recycling. It did not consider disposal by incineration as a waste reduction option due to its' inconsistency with the wise use of resources, and the significant opposition to incineration by a number of Task Force representatives. Neither did it consider the effects that disposal techniques such as incineration and landfill have on package design.

During the Protocol's development, the Task Force commissioned a number of technical reports on many issues relating to the management of packaging. These included such topics as packaging design and manufacturing, consumer uses and attitudes, environmental and economic considerations, and legislative initiatives.

The National Packaging Protocol

Consultations on the development of the National Packaging Protocol culminated in March of 1990 with its adoption by the CCME Ministers. The Protocol has six recommended packaging policies, and four milestone targets, that form the basis of an Action Plan designed to achieve a 50% reduction in the amount of packaging waste sent for disposal by the year 2000. The policies are as follows:

Policy Number 1. All packaging shall have minimum effects on the environment.

The environmental impact of packaging extends beyond the effect of its disposal; the quality of packaging waste is not the only issue. Resources and energy are consumed to produce and transport packaging. A consideration of broader environmental consequences should be included in an assessment of the impact of packaging.

The Protocol will address these broader consequences through the preparation of environmental profiles for each type of package. This will be followed up by product design to minimize adverse environmental impacts. The Protocol will stimulate research and the development of new packaging products which have minimal effects of the environment.

Policy Number 2. Priority will be given to the management of packaging through source reduction, reuse and recycling.

The federal government, in consultation with industry and the multi-stakeholder group, will establish a "Code of Preferred Canadian Packaging Practices", to guide industry in the design of products and in the selection and design of packaging according to the following hierarchy of desirability:

1. No packaging
2. Minimal packaging
3. Reusable packaging
4. Recyclable packaging and packaging containing recyclable material.

Policy Number 3. A continuing campaign of information and education will be undertaken to make all Canadians aware of the function and environmental impacts of packaging.

Responsibility for the management of packaging is shared. Achievement of the National Packaging Protocol targets requires the combined resources of government, industry, consumer and special interest groups. Education programs are necessary, both to inform and motivate purchasers to make appropriate choices, and to support the development of a conserver society. Canadians need to be informed of the functions, as well as the environmental impacts of packaging, so that they can be encouraged to make environmentally sound purchasing choices.

Policy Number 4. These policies will apply to all packaging used in Canada, including imports.

It is important that the National Packaging be applied to all packaging, domestically produced and imported from other countries. Regardless of its country origin, all packaging used in Canada will require management in Canada. Policy Number 4 will ensure a level playing field and prevent any packaging product from gaining a competitive advantage at the expense of the environment. Efforts will be undertaken to ensure effective monitoring of border markets against the entry of non-complying products.

Federal, provincial and municipal governments will, with sensitivity to the needs of local industries, establish standards and regulations to apply the National Packaging Protocol to all packaging used in Canada, including imports. The federal government will act as liaison with other countries to promote the policies of the National Packaging Protocol with respect to international trade.

Policy Number 5. Regulations will be implemented as necessary to achieve compliance with these policies.

Monitoring the process achieved through voluntary initiatives may indicate a need for regulatory measures to ensure that the effects of the National Packaging Protocol are felt equally, and that targets are met. Federal and provincial governments will, in consultation with the multi-stakeholder group, develop a recommended legislative and regulatory framework which is consistent across Canada. This framework will specify performance requirements, targets and deadlines for achievements consistent with the National Packaging Protocol.

Policy Number 6. All government policies and practices affecting packaging will be consistent with these national policies.

In environmental and other public policy areas, existing and new government policies will be reviewed to ensure consistency with the National Packaging Protocol. Health, safety, technical and other factors must not be compromised, however, they will need to be assessed in order to identify conflicts or barriers to the achievement of the objectives of the National Packaging Protocol.

Government policies and practices which impede the objectives of the National Packaging Protocol will be identified and, where possible, removed or modified. Government policies and practices such as procurement will be developed and implemented to support the achievement of the objectives of the Protocol.

The six packaging policies constitute the basis for the development of a plan of action, with specific waste reduction targets and schedules. These aim to reduce the amount of packaging waste sent for disposal by 50 per cent from 1988 levels, by the year 2000.

Milestone Targets

The National Packaging Protocol has set a number of targets as cumulative national goals. As has been noted, a regulatory framework is being prepared for quick implementation in the event that targets are not met voluntarily.

The National Packaging Protocol has established a series of four milestone targets:

By December 31, 1990, all provinces must have in place a nationally coordinated data collection program to make possible the monitoring of the following targets.

By December 31, 1992, packaging sent for disposal in Canada shall be no more than 80 per cent of the amount sent in 1988.

By December 31, 1996, packaging sent for disposal in Canada shall be no more than 65 per cent of the amount sent in 1988.

The Protocol also dictates that 50 per cent of the packaging waste reduction shall be achieved through new source reduction and reuse initiatives. Recycling programs will make up the remainder. Packaging waste reductions are to be measured in weight and are absolute numbers, i.e. they are not per capita, or adjusted for population or economic growth.

Specific targets will be established for various industry sectors, in order to achieve Protocol goals. It is incumbent on those industry sectors unable to meet Protocol requirements, to provide adequate supporting documentation and alternative targets, one year in advance of the prescribed deadline.

Although these milestone targets may be considered aggressive, the Canadian Council of Ministers of the Environment, and the National Packaging Task Force, firmly believe the Protocol's targets and objectives are realistic and attainable and every effort will be made to achieve them.

Implementation

The work of drafting the National Packaging Protocol has been completed. The task of realizing the objectives of the Protocol and actually reducing the amount of packaging waste sent for disposal, has begun in earnest. Various activities are well underway to ensure the Protocol's targets become a reality.

The National Packaging Task Force and its multi-stakeholder group have been charged with the task of implementing the Protocol. During the Protocol's development, an "Agenda for Action" was outlined and was considered to be a important tool that would specify the types of activities that should be initiated, as well as the associated time frames. Priority actions were identified, and several sub-committees have been set up to work on these key activities that are closely linked to the six specific policy statements that make up the Protocol.

Agenda for Action

1. The National Packaging Monitoring System

One of the fundamental weaknesses in comprehensive waste management strategies in most jurisdictions in Canada today, is the inadequate, knowledge of the qualitative and quantitative components of the waste stream. This often results in decisions being made based on what is perceived to be the problem, rather than a good scientific base. The National Packaging Task Force recognized the need to have a much more reliable data base of information, in which to track the progress towards meeting the packaging waste reduction targets. Consequently, the first milestone target of the NAPP, was to develop a "Nationally Coordinated Data Collection and Monitoring System" by December 1990.

The specific objectives of this data base are:

1. To identify and track the amount, and fate of packaging produced, used and consumed in Canada.

2. To monitor progress towards meeting the NAPP targets.

3. To help identify any obvious barriers to progress.

4. To assist governments in making significant policy decisions on waste management strategies at the provincial and national level.

The National Packaging Monitoring System (NPMS) will collect packaging data from two major sources, Statistics Canada and individual establishments. The information from individual establishments will be collected from an annual survey of a representative sample of companies in Canada. Companies will be asked to provide information on packaging depending upon whether they are a producer, user and/or a consumer of packaging. Included in this system is the ability to track the amount of packaging that is imported into, and exported out of, Canada.

The NPMS will collect the amount, by weight, of packaging in Canada and produce aggregate information reports according to these major characteristics:

- Industry Cluster - each company in Canada has been grouped into one of 31 industry sectors as defined by their respective SIC Codes (Standard Industry Classification).
- Packaging Cluster - all packaging materials currently in use in Canada, have been grouped into 36 non-overlapping packaging types, spanning the seven major materials i.e. plastics, glass, wood, paper, textiles, multi-materials and metal), and described according to the Statistics Canada (HS) Harmonized System.
- Year - data will be collected on an annual basis in order to maintain an efficient and reliable base of information, and to determine the effectiveness in meeting the interim targets.
- Jurisdiction - each province in Canada will be able to determine the relative performance of their province in relation to the National goal.
- Packaging fate - data will be collected in order to determine the production, use, reuse, recycling and disposal rates of packaging materials.

In May/June of 1991, Statistics Canada distributed questionnaires to approximately 10,000 establishments in Canada on behalf of the CCME, requesting very specific information on packaging for the year 1990. In addition, a census of primary and secondary processors of recycled materials will determine the amount of materials that are not only returned for recycling from industrial sources, but also from municipal collection systems, such as blue box programs. The data collected from individual companies, will be maintained by Statistics Canada and its disclosure subjected to the normal rules of confidentiality that are inherent in any Statistics Canada survey. Only aggregate information, as described by the previously noted characteristics, will be available to the major users of the data, provincial and federal environment ministries.

2. Legislation & Regulatory Development

When the National Packaging Protocol was adopted in March 1990, the CCME recognized that the development of a legislative and regulatory framework to support the Protocol's objectives was a priority. To this end, the National Packaging Protocol Legislation Sub-Committee has produced a proposal which outlines the elements that should be included in comprehensive packaging legislation.

This Sub-Committee was comprised of representatives from Environment Canada, Justice Canada, several provincial Task Force Representatives, Canadian Environment Law Association, GPMC, CTRC, PAC and the Federation of Canadian Municipalities.

The work of the Sub-Committee is broken down into two distinct phases. Phase I is the development of nationally consistent enabling legislation, that would give the appropriate federal or provincial jurisdiction the authority to regulate in any of the areas considered in the packaging legislation. Phase II, is the more controversial and detailed work, which involves outlining the specific wording and contents of the regulations that would be needed to achieve the objectives outlined below.

The specific objectives of the NAPP Legislation, Regulatory, Development are:

1) To promote National Uniformity and Harmonization towards packaging legislation by all jurisdictions.
2) To create a "level playing field", both within Canada and internationally for packaging producers and users.
3) To ensure the NAPP Packaging Waste Reduction Targets are met.

The Phase I activities of the subcommittee completed to date include a status report outlining the extent of existing packaging legislation in Canada. The group compiled and prioritized a comprehensive list of what specific legislative initiatives may be required to fulfill the objectives of the Protocol. Due to the fact that many relevant jurisdictional responsibilities are shared, the subcommittee determined which elements of packaging legislation should be provincial and those that are of national significance, and consequently may involve the federal government. Upon completion, these recommendations for provincial and federal elements of enabling packaging legislation were adopted by the CCME. It is now up to each individual jurisdiction to include it in their own specific legislation. It must be noted that the vast majority of the elements in this report are not new. In most cases, at least one jurisdiction in Canada has the authority to accomplish one or a number of the elements.

Phase II activities relating to regulation development, begun in May, so that the completed package will be ready by 1992 in the event that voluntary actions by industry do not achieve the first target.

3. Communications

The communications sub-committee was formed in April 1990 to assist the National Task Force on Packaging in fulfilling its commitments in the area of communications. The sub-committee is composed of representatives from industry, government and non-government organizations.

The mandate of the communications sub-committee is derived from Policy 3 of the National Packaging Protocol (NAPP). Accordingly the sub-committee has two main functions:

1. Promote the NAPP, the implementation of specific policies, the technical projects according to the action agenda of the Task Force.
2. Develop a national program that will inform all Canadians of the functions and environmental impacts of packaging and encourage environmentally sound purchasing practices.

In order to achieve these functions, the sub-committee has developed a communications plan as a priority activity. This plan has been endorsed by the CCME and received funding for activities in 1991/1992.

The plan consists of three main activities:

1. Speakers Program

    (a) speakers kit - generic speeches, presentation tips, overheads, publications, fact sheets (Produced)
    (b) video - 6-8 minutes, primarily for industry highlighting initiatives to reduce packaging wastes
    (c) display - portable generic display for use as backdrop at speaking and media events

2. Media Relations Program

    (a) media kit - same as speakers kit, including backgrounder, contacts and information for media contacts
    (b) "feature article bank" - articles, summaries of technical papers, case histories and testimonials, camera ready feature articles and fillers

3. Publications Program

    (a) brochure - "You Can Make A Difference" (Produced)
    (b) guide - Code of Preferred Canadian Packaging Practices"
    (c) fact sheet series - three fact sheets on packaging
    (d) poster - aimed at households

4. Code of Preferred Canadian Packaging Practices

Policy #2 of the protocol states that "Priority will be given to the management of packaging through source reduction, reuse and recycling". In view of this policy, an important activity was assigned to the federal government which is as follows; "The federal government, in consultation with industry and the multi-stakeholder group, will establish a Code of Preferred Canadian Packaging Practices to guide industry in the design of products, and the selection and design of packaging".

To this end, industry has taken the initiative to prepare the first draft of this Code for discussion with the remainder of the Task Force. More recently, the federal government has taken stewardship of the Code to ensure that all stakeholder views are incorporated.

The Code consists of a policy statement that is focused on getting a commitment from industry to design, manufacture, use and dispose packaging, in such a way, that the 3R hierarchy of source, reduction, reuse and recycling maximizes the diversion of packaging from the waste stream, thereby achieving the Protocol's targets and objectives. The Code also recognizes the various functions of packaging including important points that packaging must maintain the integrity of the product and insure that all consumer health and safety regulatory requirements are fulfilled.

The Code will be released to the public in November of 1991.

5. Life Cycle Analysis

The National Task Force on Packaging has committed itself to execute work in the field of Life Cycle Analysis and to provide a common basis for the conduct of life-cycle analysis for making packaging choices. The Protocol has outlined three specific actions to be undertaken:

1. The federal government, in consultation with a multi-stakeholder group, will undertake the development of methodologies and guidelines to be used in conducting environmental profiles of packaging, thus allowing users to compare packaging choices.

2. Industry will undertake environmental profiles of their packaging in accordance with the above federal government guidelines, to identify the environmental impacts generated through manufacture, use and post-use management of their packaging.

3. Based on profile outcomes, industry will prepare action plans and schedules to minimize environmental impacts and manage packaging through source reduction, reuse and recycling approaches.

The Task Force sub-committee developed a work plan to develop a flexible tool to assess the environmental impacts associated with packaging. This tool is to assist decision-making by the interest groups discussed earlier. It is thus essential that life-cycle analysis be recognized for what it is: a tool for assisting the decision-making process in minimizing and reducing the environmental impact of products.

The objectives of the sub-committee's workplan are threefold:

1. to identify the implications associated with the use of life-cycle assessments for packaging;
2. to revisit underlying technical and methodological issues of past and present product assessments;
3. to propose a framework which will meet the needs of the users identified above and recognize regional diversity as well as provide a nationally consistent approach in making environmentally sound packaging choices.

The work of the Task Force is also building on work ongoing in the United States. Last August, the Society of Environmental Toxicology and Chemistry (SETAC) sponsored a workshop to discuss life-cycle studies among industry, environmental groups, academia, and LCA researchers. The proceedings from the workshop identify three important phases in a life-cycle analysis: inventory, impact analysis and improvement analysis. Current work undertaken by the U.S. Environmental Protection Agency involves developing a methodology for each of the phases of life-cycle analysis. Canada is participating in these activities through the Peer Review Group for EPA's Life-Cycle Analysis Research.

6. Guiding Principles for Environmental Labelling and Advertising

A recent initiative, spearheaded by the federal Department of Consumer and Corporate Affairs, was the development of some guiding principles for the use and misuse of key environmental terms, phrases and logos. In consultation with Industry, consumer and environmental groups as well as Environment Canada and the National Packaging Task Force, these principles are intended to bring order to the marketplace especially pertaining to the recent wave of green marketing that is widespread all over Canada. Within the context of the Consumer Packaging and Labelling Act and the Competition Act, the document contains broad prohibitions on the use of such vague terms as "Environmentally friendly, ozone friendly or green" so as to prevent misleading or false advertising. In addition, the document spells out very clearly the terms by which absolute claims such as recyclable, recycled/recycled content and degradable and the mobius loop logo, may be used.

The following principles are the key elements of the document;

1. Industry is responsible for ensuring that any claims and/or representations are accurate and in accordance with the relevant legislation.
2. Consumers are responsible, to the extent possible, for appropriately using the information made available to them in labelling and advertising, thereby enhancing their role in the marketplace.
3. Environmental claims and/or representations that are ambiguous, vague, incomplete, misleading, or irrelevant, and that cannot be substantiated through credible information and/or test methods, should not be used.
4. Claims and/or representations should indicate whether they are related to the product or the packaging material.

Copies of this report can be obtained by calling the Department of Consumer and Corporate Affairs at (819) 953-1075.

Conclusions

In conclusion Industry and consumers alike must embrace the concept of Product Stewardship including the Cradle to Grave Management of waste materials. It is important that all sectors of Industry assume their fair share of the responsibility to ensure that packaging materials that they manufacture, use and consume is diverted from disposal. In addition, it is incumbent upon consumers to ensure they do their part by recycling or reusing packaging materials when reasonable access is provided to them.

Given the success of the Protocol to date, the federal government would much prefer to work with industry through a cooperative, consultative dialogue rather than extensive legislation and regulation to achieve the Protocol's targets and objectives.

Industry, as well as all stakeholders in this issue, should view the reduction of packaging waste generation and many other environmental concerns from a "Continuous Improvement" standpoint. One must not be complacent with limited success, but rather strive for environmental perfection in all facets of operations.

The Protocol was built on a cooperative effort of industry, governments and public interest groups. It is important that this initiative succeed as it will set a precedent for industry/government cooperation through "voluntary compliance". As well, it will reinforce the importance of the CCME and the need for federal/provincial harmonization and inter-provincial consistency on national environmental issues.

What's in our Landfill?

(Qu'y a-t-il dans nos sites d'enfouissement)

William Rathje
University of Arizona
Tucson, Arizona

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Texte non reçu au moment de mettre sous presse

Overview of Recycling in Europe

(Aperçu du recyclage en Europe)

Klaus Rudischauser
European Economic Community
Brussels, Belgium

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Texte non reçu au moment de mettre sous presse

Designing the New Community: Source Reduction, Collection and Materials Processing in a 21st Century Community

(Concevoir une communauté nouvelle :
la réduction à la source, la collecte et le
traitement, des matériaux dans
la communauté du 21ième siècle)

Kevin Murray
Camp Dresser & McKee Inc.
Cambridge, Massachusetts

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THE "NON-ECONOMICS" OF MANDATED SOURCE REDUCTION AND RECYCLING PROGRAMS

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Introduction

Mandated source reduction and recycling laws are making sweeping changes in the solid waste management scene of the 1990s. Some of the forces driving this legislative movement include: (1) the vanishing capacities of our existing landfills, (2) the rapidly rising costs of new landfills, and (3) a trend towards greater environmental activism in the public and political arenas. While waste reduction goals are praiseworthy and beneficial, public trust demands we ask ourselves: Are we doing it right?

Recently California, like several other states in the U.S., adopted mandatory recycling/ waste reduction goals of 25 percent by 1995 and 50 percent by year 2000. With the threat of civil fines of $10,000 per day for noncompliance, every city and county in the state is now required to prepare waste generation studies and integrated waste management plans in a relatively short time. Most of these plans have now been submitted to the state in draft form.

The economics (or in some cases the "diseconomies") of these plans is the focus of this paper. To this end, their feasibility and cost-effectiveness are examined using illustrations from various California and U.S. communities.

Five Tests of Feasibility

Public works projects should pass five tests of feasibility prior to funding and construction:[1]

1. **Engineering Feasibility**: Will it work?
2. **Economic Feasibility**: Is the benefit/cost ratio greater than 1?
3. **Financial Feasibility**: Can the money be raised?
4. **Political Feasibility**: Can the necessary approvals be secured?
5. **Social Feasibility**: Will people use it?

Although seldom publicly discussed, these tests offer prudent guidelines for elected officials making the decisions.

When California's mandatory waste reduction law, commonly referred to as "AB 939," was passed, lawmakers assumed it passed three of these tests: (1) engineering feasibility - because the technologies, while still evolving, were already proven successful by existing recycling and source reduction programs; (2) political feasibility - because it was secured from the top-down: state legislators were the primary advocates for this law rather than the private sector, the public sector, or local elected officials; (3) social feasibility - it was presumed that an environmentally conscious state such as California would embrace the concept. The recent escalation in recycling rates for beverage containers, aluminum, and glass containers into the 80 to 90 percent range appears to bear this out[2]. But what about economic and financial feasibility?

Economic and Financial Feasibility: Says Who?

Textbook resource economics tells us that "... in government, there are no forces which operate to reveal the cheapest methods of performing public functions and to induce or compel the government to adopt such methods."[3] In other words, due to a lack of economic or market incentives, public funds are often allocated in the most politically expedient manner rather than on the basis of objective evaluation. Such is the case with California's AB 939 law. Although the procedural path of public review and comment may have been followed, this law was enacted before most cities and counties could comprehend its fiscal and administrative implications or voice their objections.

There is little evidence that legislators adequately evaluated the economic feasibility or cost-effectiveness of the programs necessary to meet the waste reduction goals. AB 939 left the chore of selecting specific programs in the hands of local officials. Nevertheless, many local jurisdictions felt the requirements were burdensome and lacking in cost effectiveness. For example, the Los Angeles County Board of Supervisors recently asked the assemblyman who sponsored AB 939 to revise this law. In their opinion, the current law "requires an undue degree of costly and cumbersome planning functions ... that could be more effectively accomplished on a statewide basis."[4]

Although local officials select the recycling programs, their options are limited. To reach the waste reduction goals, they must adopt: (1) recycling, (2) composting of yard wastes, and (3) source reduction programs. Public education and programs are typically included as subcomponents of these three programs.

The state legislature also skirted the issue of financial feasibility. Mechanisms for state funding were not provided in AB 939, other than to require the local government to identify their means of funding. In California's El Dorado County, voters defeated an attempt to raise funds through an existing Community Services Area fee. In Tuolumne County, attempts to pass a $120-per-household annual solid waste management fee drew more than 500 angry citizens to the County Board of Supervisors meeting. Using a different approach, other small California counties, such as Shasta and Siskiyou, essentially decided how much they were willing to spend and then selected programs within these amounts.

Even before the state legislature adopted AB 939, the City of Los Angeles mandated waste reduction programs for city-collected residential wastes. In an approach similar to that of the state legislature, Mayor Tom Bradley announced that the City would reduce its wastestream by 50 percent within 5 years. A team of consultants estimated the costs for various alternatives to meet this goal would be in the $100- to $150-million-per-year range. Largely due to these immense costs, the City Council committee overseeing this matter delayed implementation of the program while they re-examined the feasibility of achieving the 50 percent reduction within the 5-year time frame.

Although the city is now aggressively pursuing this goal, this is a good example of what happens when the objective evaluation occurs after rather than before adoption of the plan: often the proposed programs do not pass the political, economic, and financial tests of feasibility until the objective evaluation is completed.

Cost-Effectiveness: Why Should We Care?

The primary purpose of economic analysis is commonly thought to be "the wise allocation of scarce resources among alternative uses to satisfy human needs and wants." In contrast, cost-effectiveness analysis attempts to estimate the costs of project alternatives offering the same or at least very similar benefits. This means asking: "What is the cheapest way to achieve 25 and 50 percent waste reductions?"

To help examine this question, Table 1 compares the costs of various types of waste reduction programs in California. These data measure cost-effectiveness to a large extent because each community had adopted a set of programs to meet the same set of benefits: 25 and 50 percent waste reductions.

This table indicates that the average cost of the overall source reduction and recycling elements (SRREs) for the cities and counties included here was $42/ton. However, these costs ranged from around $6/ton for Shasta County to $122/ton for Sacramento County. Source reduction programs appear to have very reasonable costs, averaging around $15/ton, but the recycling and composting programs averaged $47 and $59, respectively. Part of the reason for the differences in these costs is the level of aggressiveness of these programs. All costs used amortized capital costs for the equipment and facilities using 5-, 7-, or 15-year depreciation schedules. The costs of the source reduction, recycling, composting, and overall SRRE programs are illustrated in Figures 1 and 2.

The costs in this table are, at least conceptually, the gross costs of the programs and do not account for the revenues gained from recycling materials or the avoided costs of landfilling (i.e., the savings realized from landfilling less waste). Unfortunately, these figures do not always account for all the real costs. For example, the costs shown for the City of Irvine are the city's costs, but most of the programs are performed by private contractors, who bear most of the actual costs of implementation. Also, these costs often reflect wishful thinking while reality turns out to be much different. This point is painfully illustrated by a recent article in the *Wall Street Journal*, which states: "The proposal by the hard-pressed government of New York City to suspend its recycling program for a year is a direct result of the high cost of recycling. At around $300 per ton, the cost has proven to be well in excess of the $65 per ton that was originally estimated.[3]"

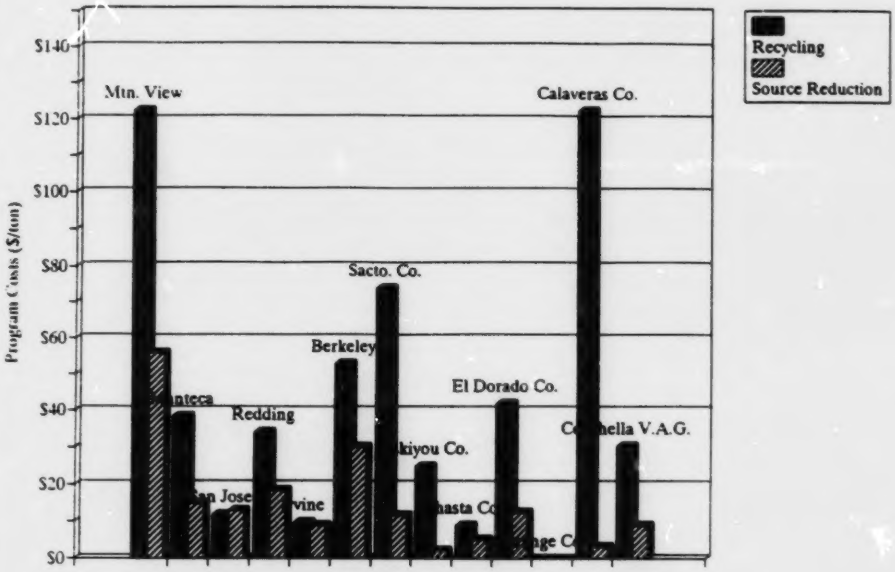

FIGURE 1

COMPARISON OF SOURCE REDUCTION AND RECYCLING PROGRAM COSTS (IN $/TON)

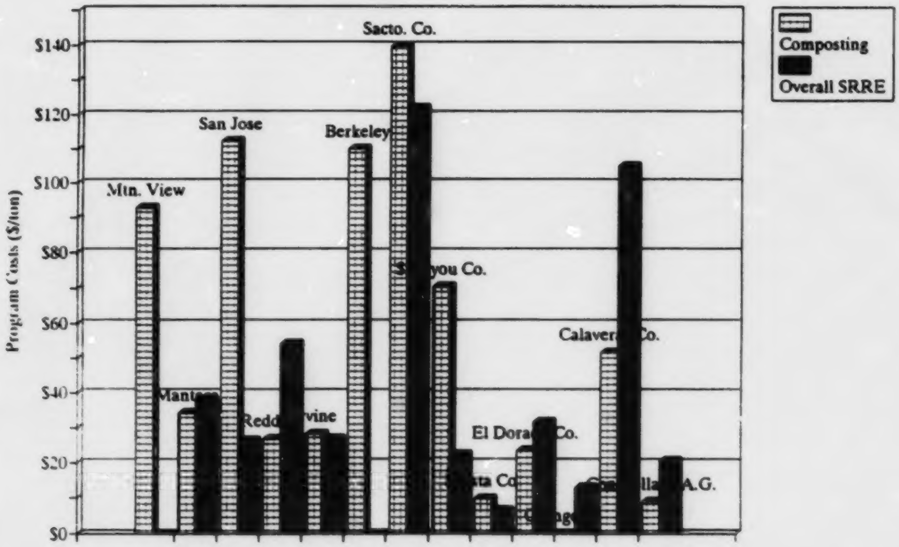

FIGURE 2

COMPARISON OF COMPOSTING AND OVERALL SRRE PROGRAM COSTS (IN $/TON)

Table 1
ESTIMATED COSTS OF SELECTED RECYCLING PROGRAMS IN CALIFORNIA
(in $/ton)

Location	Source Reduction	Recycling	Composting	All Programs
1. Mountain View, City of	$56.00	$122.40	$92.90	n.a.
2. Manteca, City of	14.70	38.30	34.40	$38.10
3. San Jose, City of	12.90	11.80	112.20	26.20
4. Redding, City of	18.20	34.10	26.80	54.30
5. Irvine, City of	8.90	9.60	28.30	26.80
6. Berkeley, City of	30.00	53.00	110.00	n.a.
7. Sacramento County	11.40	74.00	139.50	122.00
8. Siskiyou County	2.00	24.90	70.50	22.40
9. Shasta County	4.90	8.70	9.90	6.46
10. El Dorado County	12.30	41.80	23.40	31.60
11. Orange County	n.a.	n.a.	n.a.	12.90
12. Calaveras County	3.00	122.40	51.70	105.00
13. Coachella Valley A.G.	8.70	30.20	8.90	20.50
Unweighted Ave.	$15.25	$47.60	$59.04	$42.39

Note: Costs are draft Source Reduction/Recycling Elements of each jurisdiction and are calculated using the program costs and tonnages of waste reductions noted in these plans.

Aside from these problems, the net cost to the city or county are calculated by subtracting materials revenues and avoided costs from the gross costs. A net savings (i.e., without comparing recycling to landfill disposal or other options) would, therefore, occur when total costs of the programs are less than the revenues plus avoided cost savings. In contrast, the break-even point is a net cost of zero, where the revenues from recycled materials plus the credits for avoided costs equal the cost of the recycling programs.

Recycling advocates often claim businesses can achieve a net savings by recycling if avoided collection/disposal costs and materials revenues are considered[6]. However, documenting net savings for public/municipal programs is often more difficult. The fact that the gross costs shown in Table 1 did not include materials revenues or avoided costs suggests that revenues and avoided costs must be in the $20 to $100/ton range to reach this break-even point. Unfortunately, achieving the break-even point is not possible for composting programs, because the market value of compost is generally estimated to be almost zero. Other programs, such as source reduction, do not produce any recycled materials revenues per se, but can contribute through avoided costs of disposal.

However, in evaluating recycling programs, break-even analysis is only one of many ways to measure financial performance. Cost-effectiveness is a more appropriate measure for selecting recycling programs because it measures the least cost option for accomplishing a mandatory action such as waste disposal. For example, a curbside recycling program may fall $20/ton short of reaching the breakeven point, but may be the most cost-effective option compared to $50/ton collection and disposal cost and $90/ton for waste-to-energy disposal.

Cost-effectiveness analysis can be used to select and implement the least cost programs first and progressively select the next lowest cost programs until the 25 and 50 percent reduction goals are met. Determining the cost-effectiveness and/or break even point of recycling programs necessitates better understanding of avoided costs and the factors affecting recycling materials revenues. These topics are discussed below.

Avoided Costs: What are They?

As stated in a recent article in *American City and County Magazine*:[7]- "Every locality operating a sanitary landfill should know the real cost of collecting and burying a ton of garbage. The cost includes land purchase, operation of heavy equipment used on the site, monitoring wells, inspection staff, liner, drainage, structures, and the steps necessary to properly close the landfill." These costs can be segregated into capital and O&M components, which are essentially the same as fixed and variable costs.

These costs, and their distribution between fixed and variable components, will vary from one community to another. Table 2 presents recent estimates of the tipping fees, which generally reflect these costs and are often thought to approximate the avoided costs for various communities.

Tipping fees and avoided costs of landfilling are affected by the location and age of the landfill. For example, landfills in many locations on the East Coast are typically more expensive[8] than elsewhere. In general, new landfills will be much more expensive than older landfills due to increasingly stringent environmental requirements. The average cost of landfilling is increasing partly because, according to EPA estimates, almost one-third of American landfills will close by 1994[9] and will be replaced by more costly ones.

However, historical or projected costs of landfill disposal may not be an accurate measure of avoided costs. And historical tipping fees are almost never a good measure

Table 2
EXAMPLES OF LANDFILL TIPPING FEES

Source	Year	Tipping Fees ($/ton)	
		Nominal $	1991 $
Waste Age, March 1988, p. 90	1988	22.00	24.70
NSWMA - Tip Fee Survey, 1/3/87			
National Average	1987	20.36	25.00
Long Beach	1987	9.50	11.50
Richmond	1987	20.29	25.00
San Diego	1987	8.00	9.70
Sacramento	1987	8.50	10.30
Massachusetts	1987	50 to 75	61 to 92
New York	1987	25 to 55	31 to 67
California Waste Management Board, Landfill Gate Fee Survey, August 1988	1988	10 to 11	11 to 12
California Energy Commission, 1989 San Jose, (current vs. new landfills)	1989	9.50 to 17.00	10.50 to 18.50
City of Los Angeles, New Landfills	1989	30 to 40	33 to 44

Note: Conversion to 1991 dollars was calculated using the California Consumer Price Index, Department of Finance, 1991.

of the future avoided costs of landfill disposal. In evaluating recycling programs and other disposal options, the planning period may cover anywhere from 2 to 50 years, depending on the particular circumstances of the jurisdiction. The expected costs of landfilling, including new environmental controls and closure/post-closure maintenance costs, should be included in estimates of avoided costs.

According to the California Energy Commission, successful recycling will dictate increased tipping fees and landfill costs when measured in dollars per ton[10]. This is due to lower quantities of waste landfilled combined with the fixed costs of owning and operating the landfill, which do not decline with the quantities disposed. Because of this, the credit gained for avoided costs is likely to diminish due to increased tipping fees for the remaining wastes disposed, a factor that should be considered in the feasibility analysis.

Recycling Materials Revenues and Markets

Revenues gained from recycled materials and the current and projected development of materials markets is the topic of sizable debate. A report prepared by the State of California states that the economic success of recycling requires easily accessed, strong materials markets[11]. In a state as geographically diverse as California, these requirements are not always available. However, because of the critical connection between materials markets and the economic success of recycling, market development for recycled materials is likely to be a hot topic in the next 5 to 10 years. Also, one of the primary purposes of recycling in the eye of the public is to reuse the materials, not just reduce the amount of garbage going into landfills. This reuse is impossible without the industrial processing capacity to transform these materials and reintroduce them into the marketplace.

Unfortunately, the industrial processing capacity needed to handle the tremendous increase in recycled materials does not exist at this time, and is unlikely to be developed in the next few years. One effect of the lack of industrial processing capacity is that, according to classical economic theory of supply and demand, a dramatic increase in recycled materials (or a market glut) will lead to a dramatic decline in materials prices. Figure 3 illustrates this concept.

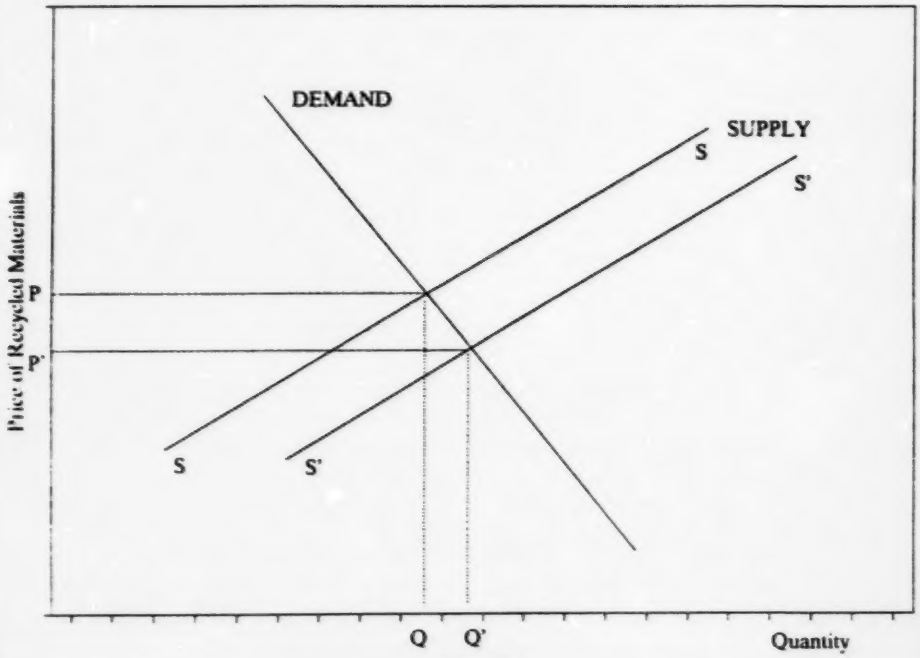

FIGURE 3
SCHEMATIC OF RECYCLING MATERIALS MARKET

This increase in recycled materials raises the following questions: (1) How much will the price drop at the various levels of increased supply? and (2) How will this affect the feasibility of recycling programs? We can say that the "flatter" the demand curve shown in Figure 3, the more sensitive (or elastic) the demand for recycled materials. In other words, a shift in the supply curve to the right (from SS to S'S') results in a greater quantity processed but at a lower price (P' instead of P).

Without further discussing the details of the price elasticity of demand, we can say that anecdotal data seem to indicate that materials prices are fairly sensitive to increases in supply. Contacts with processors[12] and local governments (e.g., El Dorado and Merced Counties) indicate that processors running at capacity may, at times, charge for accepting paper, glass, and ferrous metals. Unfortunately, few empirical studies have addressed this possibility.

Despite the current lack of materials markets, the good news is that industrial processing capacity is likely to be developed. A National Association of Counties representative stated, "If it (recycling) becomes standard and a national policy is set, then the markets will develop."[13]

For the private sector, investing in facilities and equipment to develop additional de-inking process manufacturing capacity requires two things: (1) the assurance of long-term, cheap supplies of raw materials, and (2) the reasonable expectation that there will be a strong market for recycled products.

There are already signs that this is occurring. Since AB 939 was adopted, at least two major companies, and possibly many more, have been aggressively developing newsprint de-inking/recycling plants in California. Because of stringent environmental laws and related permitting requirements, these plants are difficult to site and were it not for the mandated recycling of AB 939, private industry would not be pursuing these projects.

Mandated Programs: Proceed With Caution

Mandated waste reduction laws have led some local officials to despair about the economic realities of recycling. Mike Miller of the City of West Covina Community Services Division, California, states that in smaller cities, "We have to overcome the myth that recycling will not cost more."[14] Citrus County, Florida, found that recycling programs will cost about $2 million per year to generate about $0.5 million in recycling revenues and landfill tipping fees will have to be increased by $17 per ton[15]. As illustrated in Table 1, cost-effective recycling programs are not always reality.

These examples point out the need for careful evaluation of the economic and financial feasibility of proposed source reduction and recycling programs, as well as all environmental regulations. Even some pro-environmental experts in the field have stated that many of our existing federal regulations are just not worth the money we are spending on them[16]. This can be a serious local as well as national issue. Some experts have estimated that the cost of meeting just federal environmental regulations will approach $180 billion a year in the next decade. This amounts to roughly 3 percent of the U.S. gross national product (GNP) and could severely hamper economic growth in the U.S. economy.

Conclusions: What Do We Do Now?

This paper has discussed the economic feasibility of recycling programs and presented a few examples of real problems that city and county governments are facing in California and other parts of the U.S. This discussion has been presented with the intent of driving home two points:

1. Governmental institutions lack incentives, such as those that occur in the free market, to adequately search out the most cost-effective or feasible means of implementing worthy environmental goals. Efforts should be made to inject free market forces, and other means of objective evaluation, to help select cost effective disposal options.

2. The level of economic and financial analysis of recycling and environmental regulations should be expanded so as to enhance the social welfare of the public.

In light of this, mandated recycling laws should be thoroughly and objectively evaluated before adoption, and should clearly demonstrate net benefits to society within some reasonable planning period.

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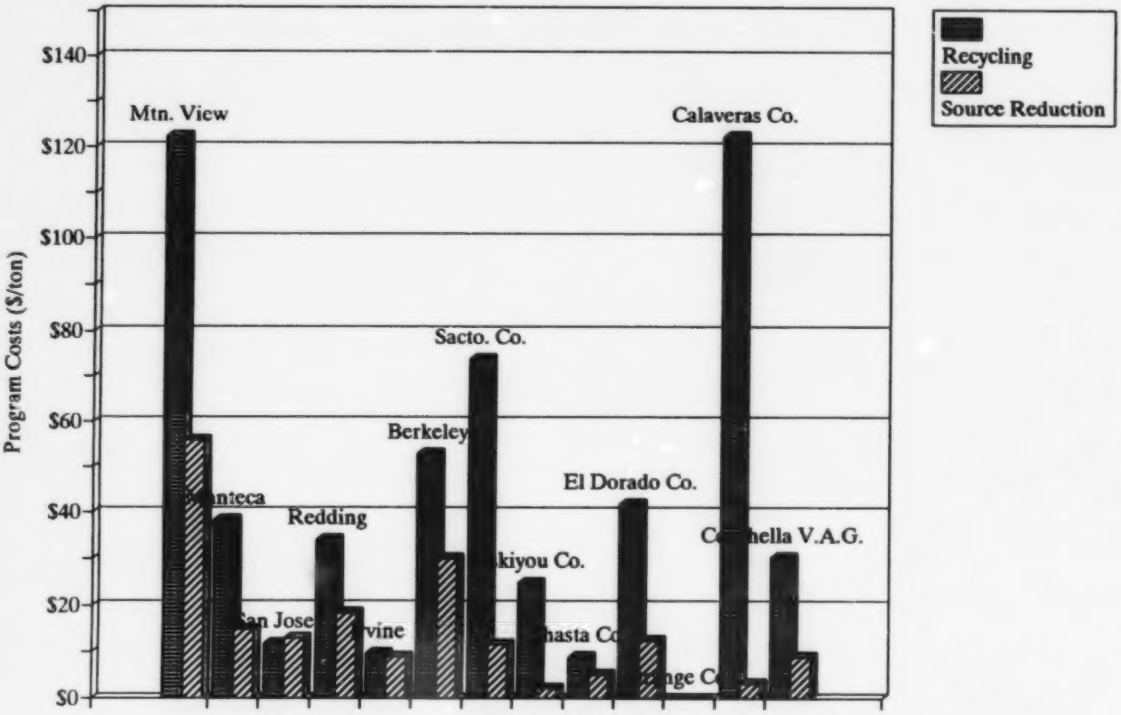

FIGURE 1

COMPARISON OF SOURCE REDUCTION AND RECYCLING PROGRAM COSTS (IN $/TON)

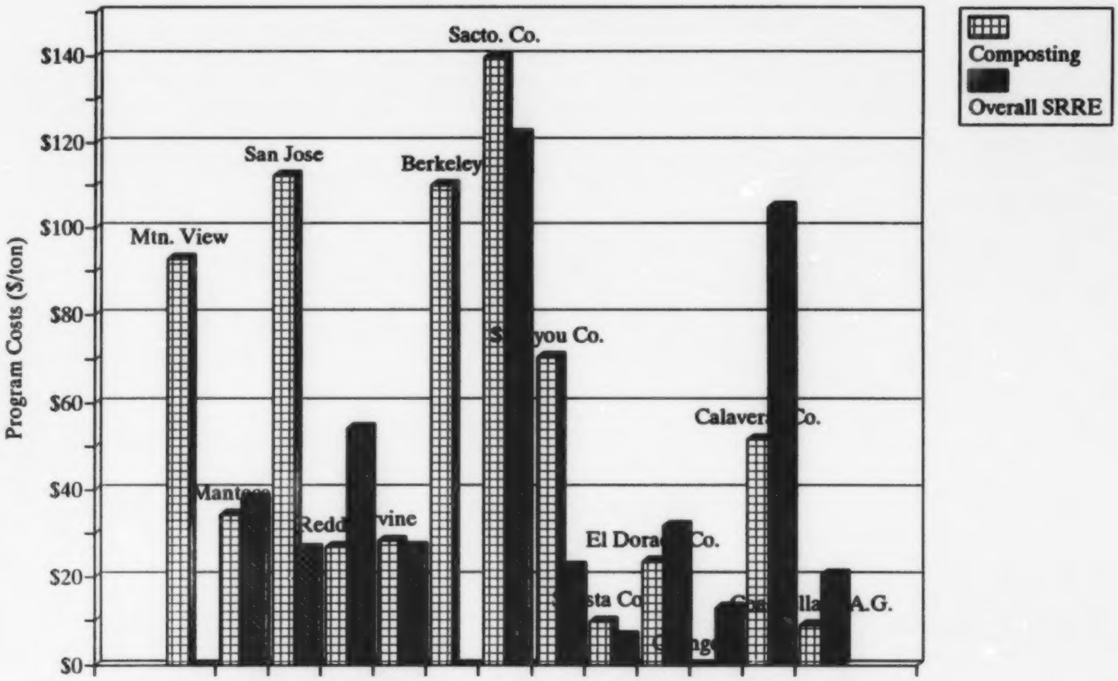

FIGURE 2

COMPARISON OF COMPOSTING AND OVERALL SRRE PROGRAM COSTS (IN $/TON)

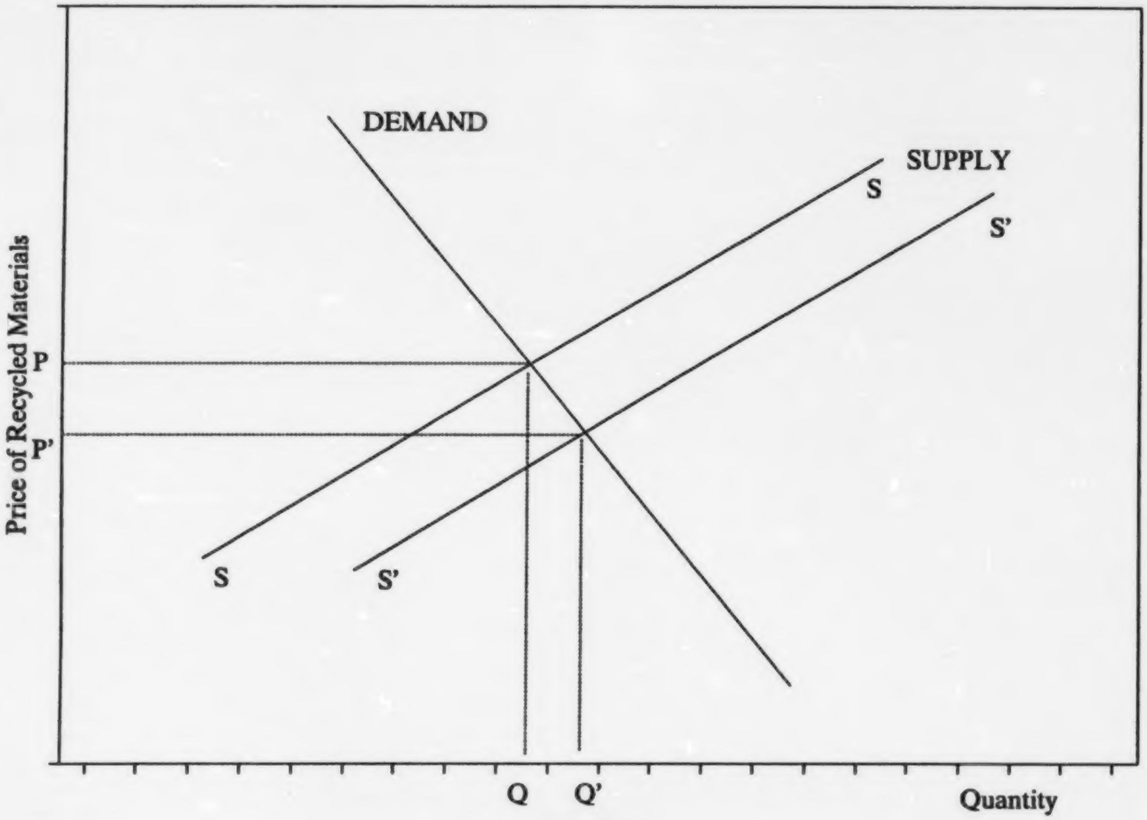

FIGURE 3
SCHEMATIC OF RECYCLING MATERIALS MARKET

Waste Reduction in the Province of Ontario

(La réduction des déchets en Ontario)

Drew Blackwell
Assistant Deputy Minister
Waste Reduction Office
Ontario Ministry of the Environment
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Do Incentives Work? Household Waste Reduction Attitudes and Behaviors

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During the last decade, waste management issues have moved from the periphery to center stage in most political discussions. This concern has been prompted by the fact that some environmental issues have reached crisis proportions. This is true in the Northeast U.S. for issues regarding solid waste. Because of limited space, more stringent requirements regarding the location and maintenance of landfills by the EPA (Environmental Protection Agency), and residential resistance to having a landfill located nearby, it is becoming more difficult to locate sites for new landfills. Faced with the increased cost of disposing solid wastes, decision makers are turning to policies that reduce the waste stream and extend the life of existing and new landfills.

User fees provide an incentive for households to reduce waste; the less garbage households put out to go to the landfill, the less they pay in disposal costs. However, many policy makers are loathe to place explicit fees on waste disposal, preferring instead to hide fees in property taxes or to use across-the-board flat rate fees for disposal.

This research addresses the issue of how households respond to several public sector incentives to encourage reductions in household waste and to encourage recycling. Specifically, this study

- assesses the attitudinal and informational issues of households faced with a user-fee program for waste removal,
- explores the distributional issues raised by the user fee,
- explores the effects of policy structures on waste reduction and recycling behaviors.

Economic Incentives and Waste Reduction

The use of financial incentives to reduce household waste is often considered but not usually implemented due to lack of public appeal. Examples of financial incentives include container deposits (a "litter tax"), variable waste disposal charges for garbage collections (user fees), deposits on durable goods (similar to beverage container deposits), and product disposal charges by weight, unit, or composition.

Economic incentives, such as user fees, have been proposed alone or in combination with regulatory measures (e.g., mandatory recycling). Arguments for the use of economic incentives are based on effectiveness, economic efficiency, and equity. Opponents of the use of economic incentives cite examples where waste reduction behaviors take place in the absence of any extrinsic motivations (see DeYoung, 1985-86 and DeYoung, 1989). Studies that look at why households/individuals engage in waste reduction behaviors try to capture the "warm glow" or intrinsic satisfaction derived purely from the participation in these activities (Andreoni, 1989).

The use of economic incentives in public policy is based on the notion that in order for environmental resources to be allocated efficiently, they should be priced as are resources in other markets (Baumol & Oates, 1979). In the case of solid waste disposal, negative externalities are created by the fact that some people overuse scarce landfill space. When an individual engages in waste reduction behaviors, the public as a whole benefits from the reduction of solid waste (and the reduced demand for landfill space). Since waste reduction behaviors are often inconvenient and costly in terms of time, there is little incentive for individuals to engage in these behaviors on their own.

Economic incentives in environmental policy attempt to internalize the negative externalities by placing an explicit price on waste disposal. A per-container-user-fee requires households to pay for each container of waste that the household creates, forcing some of the social costs to be internalized and creating an incentive to produce less waste. The per-unit fee also reflects the economic notion that increasing the marginal cost of waste disposal results in a decrease in the demand for waste disposal, i.e. less waste.

However, the incentive pricing system is not without criticism: distributive issues are an important consideration. While the wealthy may or may not decrease their waste in response to user fees, the poor may not have this choice because they cannot afford to pay higher prices. Also, it is difficult a priori for policy makers to set an efficient price: under-pricing the environmental resource will result in continued over-use, while over-pricing is not economically efficient.

Background for the Study

Tompkins County is located in central New York with a population of 94,097. Three institutions of higher education are located within the county: Cornell University, Ithaca College, and Tompkins Cortland Community College. These institutions are the major employers in the county. The result is that the demographic characteristics of the county, especially with respect to education and income, are quite different and may not allow the results to be generalized to other counties and communities.

On March 30, 1990 the Tompkins County Division of Solid Waste implemented a "trashtag" program. This program is a user-fee program that requires residents to purchase a tag for each container of garbage set out for pick-up. This program is one part of an overall waste reduction program that also includes curbside pick-up of recyclables, a central processing facility, and a home composting program. The trashtag and curb-side recycling programs are designed to work together. The trashtag program creates an economic incentive for people to reduce their household waste while the recycling program provides a convenient method by which people can reduce the household waste sent to the landfill.

This study is the result of a joint effort between the Tompkins County Division of Solid Waste, The Cornell Waste Management Institute, and Cornell's Department of Consumer Economics & Housing. It is an example of how community agencies and institutions can work together to serve local needs (see Stone, 1991a).

In September, 1990 a mail survey was sent to 3,400 Tompkins County residents. The first phase of the mailing was a postcard which served as an announcement of the survey and as an inexpensive way to determine our undeliverable rate; 366 names were deleted from the sample because of insufficient addresses.

The second phase of the mailing was the questionnaire, sent to the remaining 3,034 residents in our sample. The response rate to this phase of the mailing was 34% (1019 responses).

The third phase involved sending the questionnaire a second time to those residents who did not respond to the initial mailing of the questionnaire, approximately 2,000 residents. From this mailing 403 questionnaires were returned (20% response rate). The overall response rate (both waves) was 49%, an excellent response rate for a mail survey.

The distribution of respondents among the communities in the county was fairly representative of county residents (see Stone, 1991a). Nearly 63% were married, while 18% were single, 9% were widowed, and 8% were divorced or separated. The sample was almost equally divided among males (47%) and females (53%).

The questionnaire was sent to heads of households (adults); therefore, we expected fewer people in the younger age groups. Thirteen percent of the sample were under 30, 38% were between 30 and 44, 21% were between 45 and 59, and 27% were 60 and over. The sample was somewhat more educated than the population in the county. This may, in part, be due to the fact that people with higher educations are more likely to respond to a survey of this type. Nearly one-third (31%) had graduate or professional degrees, 21% had bachelors degrees, 26% has some post secondary training, and 16% had high school diplomas.

Nearly half the sample (48.5%) held full time jobs, with another 8% holding part time jobs. Nearly a quarter of the sample (22%) was retired and another 11% were students. Over half the households (57%) were 1 or 2 person households, while another 32% were 3 and 4 person households. The vast majority of the households (65%) had no children under 18.

Over four-fifths of the respondents furnished information on income. Among those responding, the median household income was around $35,000. The sample falls disproportionately into the higher income ranges, with 12% reporting household incomes of $75,000 or more.

The majority of the respondents (51.5%) were responsible for dealing with both the garbage and recycling in their home while most of the others (35.4%) shared the responsibility with someone else in their household. The rest were responsible for either just the recycling (3.9%), or just the garbage (5.8%).

The vast majority of the respondents (75%) lived in Tompkins County for more than 7 years with about 11% living in the county 1-3 years and another 10% living in the county 4-7 years.

General Results

Tags. About four-fifths of the respondents reported that they were required to purchase trashtags (priced at $.70 each at the time of the survey; prices have since risen to $1 per tag). Residents in apartment complexes of 6 or more units are not included in the trashtag program.

Three-fourths of the sample put their garbage out once a week, while 11.6% of the sample put their garbage out every two weeks. The majority of the sample put out either a 30 gallon can (49.8%), or a 22 gallon can (14.7%). Nearly half the sample put out a garbage receptacle that weighed between 20 - 30 pounds (the tag was limited to 35 pounds of garbage). The rest of the sample was equally divided among those who put out less garbage by weight and those who put out more. Three-fifths of the sample put out one container for pick-up and another one-fourth put out two containers. About half of the sample claims to put out the same amount of garbage (48%), and about half claim to put out less garbage (47%) since the trashtag program began.

Recycling. Nearly half the sample answered that recycling was required where they live. This finding is interesting because recycling is only mandatory in the City of Ithaca and only 28.2% of our sample lived there. This may be a misperception that the provision of curbside pick-up means that recycling is mandatory.

Nearly three-fifths (57.9%) of the sample said that curbside pick-up was available where they live. However, 69.3% of the respondents actually lived in communities with curbside pick-up available to them. This disparity may be an indication that some people are not aware of this service. The 53.6% of the sample who said that they have a drop-off center in their town came very close to the 52.8% of the sample who actually did have drop-off centers in their towns.

Over one-fourth of the sample put their recyclables out for pick-up once a week, while one-third put recyclables out less frequently. A large proportion of the sample either didn't respond to this question or didn't have curbside recycling available to them. One out of 6 respondents brought all of their recyclables to a drop-off center, while another one-third brought some of their recyclables to a drop-off center.

We tried to identify some reasons why those who don't recycle might find recycling inconvenient. Three percent reported that they didn't have access to transportation to a drop-off center. About half the sample (50.4%) lived more than 3 miles from a drop-off center. Over one-fourth had adequate but inconvenient storage for recyclables and another one-fifth claimed not to have space to sort and store recyclables.

Before the trashtag program, 55% recycled newspaper, 45% recycled glass, 27% recycled plastics, and 24% recycled cardboard. After the tag program, 80% recycled newspaper and glass, 63% recycled plastics, and 48% recycled cardboard. Shortly before the survey was sent out, curbside pick up of metal cans was instituted; 61% of respondents reported recycling cans. In addition, nearly one-fourth of the sample recycled other materials (motor oil, aluminum foil, books, clothes).

Other Methods of Waste Reduction. Nearly half the sample (47%) compost some of their waste. Most (96%) have a compost pile at home, while others shared with neighbors or used the county's compost site.

Three-fourths (76%) of the sample reported that they tried to purchase products with less packaging in order to reduce waste. Nearly two-fifths (39%) paid more attention to product packaging since the trashtag program.

There was concern that the trashtag program would result in increases in illegal dumping and burning. Over half the sample (51%) thought that illegal dumping had increased since the tag program. One-fifth reported that they burned their trash, although this is illegal in Tompkins County.

Public Attitudes

As seen in Figure 1, 63% of the respondents either "favor" or "somewhat favor" the trashtag program. The next largest group is the "somewhat oppose" category (15%). The remaining 20% either opposed, didn't care, or weren't aware of the program. While this seems an encouraging result, it's important to keep in mind the issue of potential selectivity bias when reading these results; those who favor the program may have been more likely to return the questionnaire.

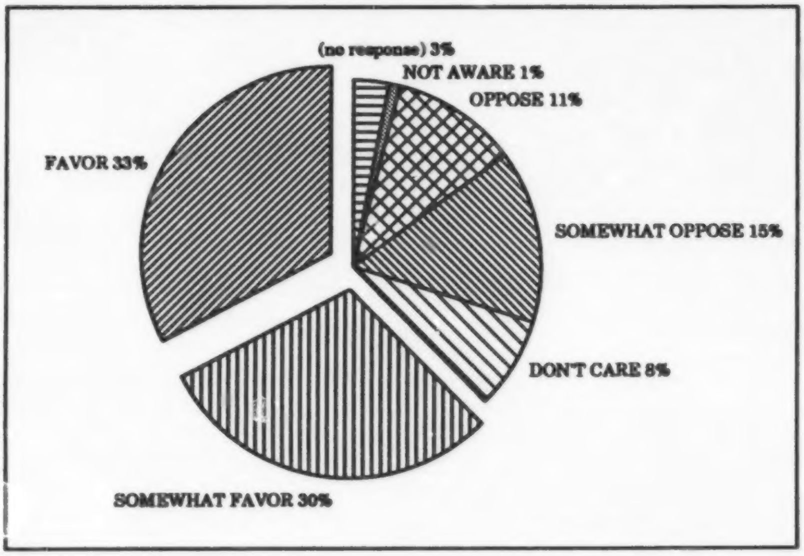

FIGURE 1. HOW RESPONDENTS FEEL ABOUT THE USE OF TRASHTAGS IN TOMPKINS COUNTY

Those who "somewhat oppose" the trashtag program were slightly less educated and tended to live in the more rural communities in the county. The "somewhat opposed" attitude is associated with slightly fewer waste reduction behaviors (recycling, composting, etc.).

At the time of the survey, the tag fee was set at $.70; 44% felt the cost of the tags was too high, and about one out of 6 had no opinion on the price. The remaining respondents felt the tags were priced about right. Again, it is interesting to note that one year later the fee rose to $1.00.

Trashtags can purchased through the garbage haulers and at various community sites (eg. grocery stores). Only one out of 12 respondents reported problems purchasing trashtags. Most of these problems related to issues of inconvenience (running out of tags, delays in dealing through the mail, frustrations at "one more errand," etc.). Clearly, finding some convenient way of distributing the tags would help public attitudes toward using them.

Because policy makers tend to shy away from user fees in favor of "hidden" fees, such as property taxes and flat-rate hauler fees, we wanted to ask how residents themselves would prefer to pay for any future increases in cost of waste disposal. As seen in Figure 2, nearly half (48%)

preferred user fees compared to flat rate fees (18%), property taxes (9%), sales taxes (8%), and income taxes (4%).

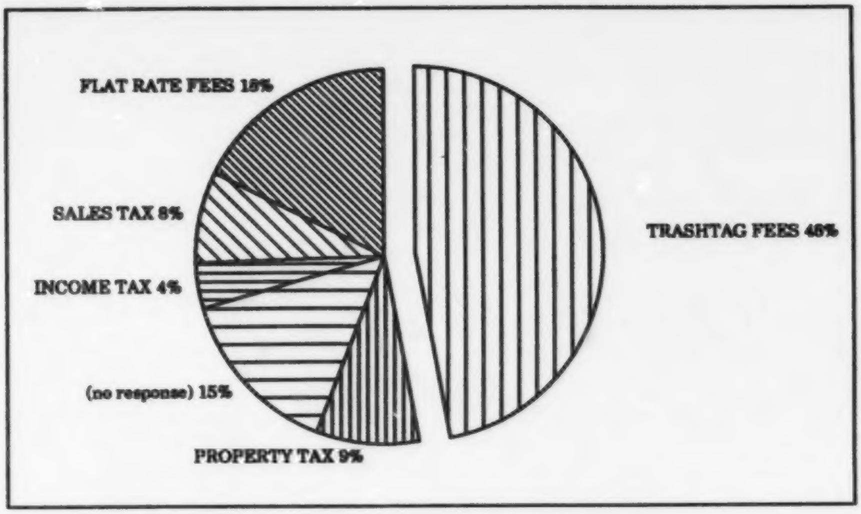

FIGURE 2. HOW RESPONDENTS WOULD LIKE TO SEE FUTURE WASTE DISPOSAL COSTS HANDLE

Information Issues

The results indicate that people felt better informed about the trashtag program than the recycling program; 80% felt well informed about the trashtag program while about 54% felt well informed about the recycling program.

Newspapers were by far the most widely used medium for community information for this sample (63%), followed by radio (16%). TV (8%), flyers (7%), and friends (6%) were cited by others. Ithaca has one daily paper (daily except Sunday) and two free weekly newspapers. The cable company which serves Ithaca has two community access channels, but not all of the county is wired for cable. Residents in outlying areas rely on commercial network stations from Syracuse, Binghamton, and Elmira for television. Thus, it is not surprising that TV was not targeted as a medium for information delivery by the county. More urban communities would need to choose a different mix of information sources to reach their residents.

The survey included a write-in section for any suggestions about how to improve the amount and type of information on solid waste and recycling programs. Many people wanted information on how to recycle items not picked up. One suggestion was that there be a printed summary of recycling rules on the back of the trashtag sheets. Another suggestion was to print recycling hours and locations in the weekend edition of the newspaper.

About 10% of the sample wanted to see more information about what types of materials can be recycled, and how to recycle. It seems that people felt that information was inconsistent and there was a lot of confusion about what kinds of materials can and can't be recycled.

At the time the trashtag program was implemented, it was expected that the county landfill would need to close in a year's time. This closure was one of the factors which motivated the county to opt for a user fee program in order to prolong the life of the landfill. When asked how long the respondent felt the present landfill would remain open, about one-fourth gave the "correct" answer of a year. More than half (59%) responded that they did not know; this is actually an accurate answer, since the landfill is still open, nearly one year after it's predicted closing.

Distributional Impact

County officials were sensitive to the fact that user fees can place disproportionate financial stress on low income families. The Solid Waste Division worked with the Department of Social Services to implement a Trashtag Assistance Program. To qualify for the assistance program, families had to also qualify for public assistance, food stamps, Medicaid, home energy assistance and/or low income daycare. During the first 6 months of the Trashtag Assistance Program, only 30% of those who were eligible for these programs requested tags from the county.

We were interested in looking at why so few requested assistance. Using the U.S. Poverty Standards which incorporate income and household size, we categorized respondents as impoverished or not. Due to data restrictions (e.g., the categorical nature of our income variable), our analysis underestimated the number of respondents who lived at or below the federal poverty level. Using this admittedly conservative technique, we determined that 65 respondents were eligible for the Trashtag Assistance Program.

Of these 65 respondents eligible for the Trashtag Assistance Program, about one-third were aware of the program while the others were not. One-fourth said they were not required to purchase trashtags because they used a dumpster, shared a garbage area with neighbors, or hauled their own garbage. Half of these respondents rent apartments or units which are not covered by the trashtag program. Only 10 of the 65 had requested tags from the Dept. of Social Services.

It is possible that some confusion may exist about eligibility requirements. At the beginning of the questionnaire we asked whether or not the respondent or any of his/her family members were eligible for the Trashtag Assistance Program. At the very end of the questionnaire we asked whether the respondent or any of his/her family members were eligible for any other assistance programs, which meant they qualified for the Trashtag Assistance Program. Of the 79 respondents who were eligible for the listed programs, 11 said they were not eligible for the Trashtag Assistance Program and 21 said that they didn't know if they were eligible.

It is important to restate the fact that the poverty categories used for this analysis underestimate the number of respondents who fall below the federal poverty standard. Even given this limitation it is interesting to note the number of respondents in these poverty categories for whom the trashtag program doesn't apply because of their housing situation. If we assume that renters in every situation except renters of a single family house and respondents who live in trailer parks, or those who live in student housing do not have to purchase trashtags, then 66% of the respondents who are in the defined poverty categories are not required to purchase trashtags. The fact that the county was reaching 30% of those eligible may mean that they are in fact reaching those who need the tag assistance program.

Waste Reduction Behaviors and Policy Structure

At the time of the survey, there were three different policy structures available to communities in the county: trashtags, curbside recycling, and mandatory recycling. Four permutations of these policies were realized in the county. One community opted to include the "price" of the tags in their property taxes and had curbside recycling available to residents; about one year later, they abandoned this policy and this community now requires trashtags. One community had mandatory recycling in addition to requiring tags and making curbside recycling available. Six communities required tags and had curbside recycling available, although recycling was not mandatory. The remaining 8 communities required tags, but had no curbside recycling, although drop-off centers were available in these communities.

Policy Structure in Tompkins County

	Trashtags	Mandatory Recycling	Curbside Recycling
Group 1	no	no	yes
Group 2	yes	yes	yes
Group 3	yes	no	yes
Group 4	yes	no	no

To test the effect of different policy structures on waste reduction behaviors, holding all else constant, we used a set of linear probability models (Stone, 1991b). The dependent variables were whether or not respondents recycled newspapers, glass, plastic, cardboard, yard waste, and metal cans. Also, we estimated an equation for persons who tried to reduce the amount of their garbage by buying products with less packaging.

Independent variables represented barriers to recycling, other methods of waste reduction, information variables, demographic variables, and policy variables. Barrier variables included miles to the nearest drop-off recycling center and lack of adequate space to store recyclables. Other methods of waste reduction included whether or not respondents burned any garbage and if they did anything else to reduce garbage. Information variables included respondent's sense of being well-informed about recycling policies and their perception of how long the county landfill would remain open. Demographic variables included household size, marital status, sex, age, education, hours in paid employment, and household income.

Five policy variables were constructed: curbside only; trashtag only; tag and curbside combination; mandatory, tag, and curbside combination; and other policies reported by respondents (e.g., mandatory only, mandatory and tag combination). Respondents not reporting any of these policies (e.g., those living in apartment complexes) were coded as facing no policy.

In general, the policy which had the largest impact on recycling was the provision of curbside recycling, which increased the probability of recycling in the 32 to 40 percent range, depending on materials. Yard and food waste was one exception to this finding; tags were the most effective policy variable in getting people to recycle yard and food waste (composting). User fees (tags) and mandatory recycling regulations each increased the probability of recycling by and additional 7 to 9 percent. The maximum probabilities for recycling were in the 45 to 60 percent range, again depending on materials (see Stone, 1991b for more details).

It is interesting to note that beginning in September, 1991, curbside recycling was made available county-wide. If the results of the above analysis are robust, we would expect to see a large increase in recycling in the Group 4 communities (above) as they switch from no curbside to having curbside pickup.

None of the policy variables were significant in increasing the probability of households buying products with less packaging. Higher levels of education, being female, and engaging in other waste reduction activities were associated with buying products with less packaging. The product and packaging mix that consumers face is just now beginning to respond to consumer demand for less packaging. In the future, consumers may have more packaging choices which will allow them to reduce household waste even more.

Summary and Conclusions

Despite the sensitivity that policy makers feel toward explicit user fees, most households in this survey favored the user fee program instituted in Tompkins County for waste disposal. Not only did 63% favor the trashtag program, but also nearly half (48%) preferred the user fee to other methods of paying for waste disposal (property taxes, flat rate fees, etc.). These figures should offer encouragement to policy makers who are considering alternative ways of funding waste disposal programs.

Perhaps one of the reasons the respondents felt favorably toward the program was that they also felt well informed about it. Over half (54%) felt well informed about the recycling program in the county (curbside pick up and drop-off centers), while four-fifths (80%) felt well informed about the trashtag program. While the majority of the respondents (63%) in this survey received most of their information from newspapers, it is probably desirable to tailor the media used for the communication/information program to the community.

User fee programs are often criticized as having disproportional effects on lower income households who can ill-afford the fees. In the case of Tompkins County, a subsidy program was developed in cooperation with the Department of Social Services. However, only 30% of those low income households eligible for the Trashtag Assistance Program requested assistance. Results from this survey indicate that many low income households lived in residence units (apartments, rooming houses) which were not covered by the trashtag program. Thus, one of the unintended side effects of excluding certain housing units is to help ameliorate the distributional effects of the user fee program.

A curbside recycling program had the largest impact on getting people to recycle. The effects of the user fee and mandatory policies were significant, but smaller in relation to the effects of the curbside program.

There are several caveats with respect to these results. Tompkins County is an extraordinary example of garnering the cooperation of the communities in the county for a truly county-wide program. Many other counties may have difficulty in securing the cooperation of communities and municipalities without significant efforts. Also, the educational and income levels of county residents is much higher that the "average" county, owing in part to the presence of two colleges and a university in the county. Thus, Tompkins County residents may be much more responsive to waste reduction programs than residents in other areas; other programs may not see the large results evidenced in Tompkins County.

Nonetheless, these results point the way to effective policies for waste removal. Curbside pick up of recyclables, mandatory regulations for recycling, and user fees are all effective in getting households to reduce waste. A comprehensive information program is helpful in promoting positive attitudes and in securing the cooperation of residents in implementing these policies. Incentives work.

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AN EFFECTIVE PUBLIC EDUCATION STRATEGY

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U.S.A.

BACKGROUND

The Group for Recycling In Pennsylvania, Inc. (GRIP) is a non-profit public interest group that was founded in 1971 in response to the first Earth Day. GRIP's mission is to promote the wise stewardship of our natural resources and energy supplies. For over twenty years GRIP has been providing public education to adults and children on recycling and waste minimization.

In the early years, GRIP operated as many as seventeen volunteer recycling centers in Allegheny County and four adjacent counties. Over the years, the markets for newspaper, glass, aluminum, and bi-metal cans continued to fluctuate. At times, there were no markets. GRIP volunteers continued to operate the centers because they felt teaching by example was an effective method of showing people how to recycle to save valuable natural resources and energy supplies. As the commercial centers began to appear in 1986, GRIP began to close its volunteer centers and focus even more energy on public education.

Every year, in the state of Pennsylvania, more than 9 million tons of household trash is generated. That's enough to fill Three Rivers Stadium, the home of the **Pittsburgh Pirates**, more than twenty times. The average family of four throws away about three tons of garbage a year--the weight of three small cars. The time has come for all of us to recognize what a "throw-away" society is doing to our natural environment and our children's future. We must come to realize that there is no "away."

The leaders in Pennsylvania have decided "it's time for action." A decision was made to do something about the solid waste crisis in Pennsylvania. In July of 1988, Governor Robert P. Casey signed ACT 101, the Municipal Waste Planning, Recycling, and Waste Reduction Act. On September 26, 1990 recycling became mandatory in Pennsylvania for municipalities with populations of 10,000 or more, making Pennsylvania the largest state in the United States to have mandatory recycling. Municipalities with a population of 5,000 or more were required to recycle by September of 1991.

The goal of PA ACT 101 is to reduce the amount of municipal waste produced in Pennsylvania by 25% by January 1, 1997. By working together the people of Pennsylvania can reach or surpass that goal. Curbside recycling programs are currently operating in 516 communities in Pennsylvania, with a total of 6.5 million residents recycling--more than half of the state's population.

INTRODUCTION

The Group for Recycling In Pennsylvania, Inc. has provided consulting services to ten local municipalities to assist them in creating an effective public education component of their recycling program: Brighton Township, Elizabeth Township, Glassport Borough, Indiana Township, the City of McKeesport, Mt. Pleasant Township, Rostraver Township, Swissvale Borough, West Mifflin Borough, and Wilkinsburg Bourugh.

From the initial notification letter, to the planning for a public meeting, to designing educational materials to be distributed with the recycling bins, GRIP has guided them every step of the way. Information was given on "why" the amount of waste produced must be reduced, along with ways to achieve that goal from careful shopping at the grocery store, to recycling and composting. The purpose of this paper is to name and describe the various steps in what has proven to be an effective public education strategy so that others from government and non-profit organizations may benefit.

RECYCLING LAW REQUIRES PUBLIC EDUCATION PROGRAM

Section 1501.(d) of PA Act 101 requires that each municipality establish a "comprehensive and sustained public information and education program" concerning recycling program features and requirements. The first step in designing an effective public education strategy was to define the components that were necessary and then to set a time line. Good planning is a key ingredient.

We soon found that not only was it important to have a good relationship with your printer, so that vital educational materials were ready on time, but there were other factors to consider. Public officials in several communities had to delay the delivery of their recycling bins to residents because it was taking the bin supplier six weeks to deliver, due to the number of municipalities ordering bins to start recycling by September 26, 1990.

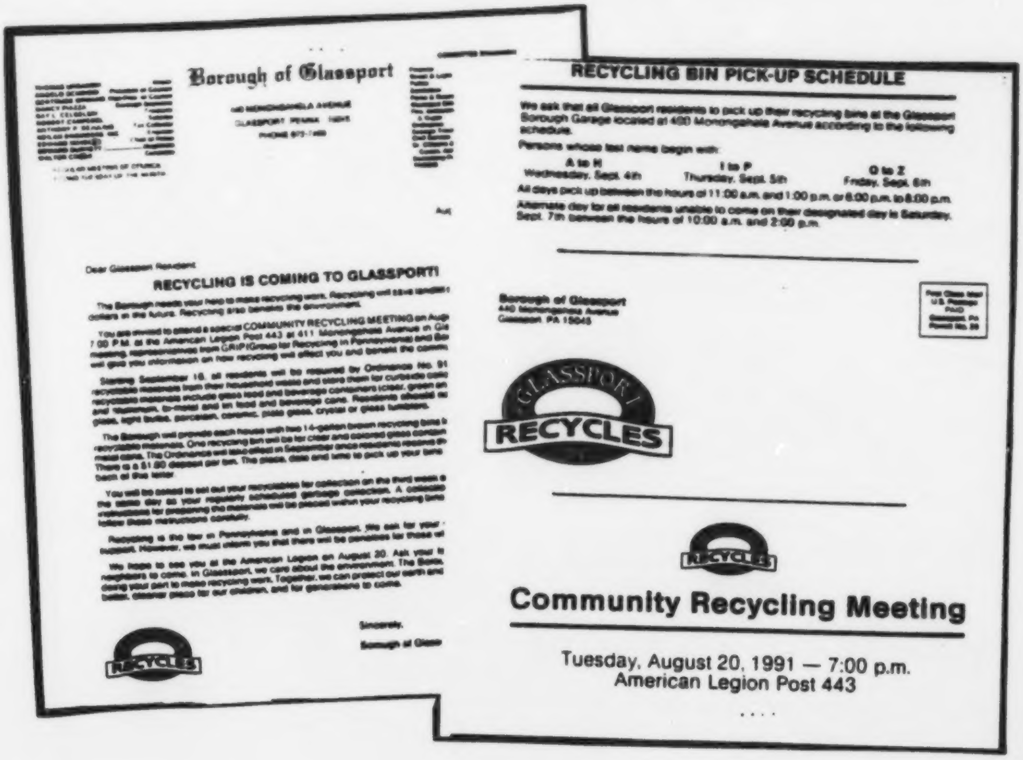
Listed below are the components selected for the public education strategy:

1. Develop a time line listing completion dates.
2. Required notification given.
3. Hold public meeting.
4. Establish Recycling Education Committee.
5. Prepare education materials for distribution.
6. Delivery or pick-up of recycling bins.
7. Present School Education Program.
8. Work with local media to give consistent message.
9. Six-month follow-up notice given.

REQUIRED 30-DAY NOTIFICATIFICATION

As part of the required public education and information program, each municipality must, at least 30 days prior to the initiation of the program and at least once every six months thereafter, notify all persons occupying residential, commercial institutional and municipal establishments of the requirements of the recycling ordinance.

To meet this requirement, municipalities could place an advertisement in a local newspaper, post a notice in public places where public notices were usually placed, include a notice with other official notifications mailed to residential taxpayers, send a separate notification mailing, or use any combination they saw fit.



Borough of Glassport

RECYCLING IS COMING TO GLASSPORT!

RECYCLING BIN PICK-UP SCHEDULE

We ask that all Glassport residents to pick up their recycling bins at the Glassport Borough Garage located at 400 Monongahela Avenue according to the following schedule.

Persons whose last name begin with:

A to H	I to P	Q to Z
Wednesday, Sept. 4th	Thursday, Sept. 5th	Friday, Sept. 6th

All days pick up between the hours of 11:00 a.m. and 1:00 p.m. or 6:00 p.m. to 8:00 p.m.

Alternate day for all residents unable to come on their designated day is Saturday, Sept. 7th between the hours of 10:00 a.m. and 2:00 p.m.

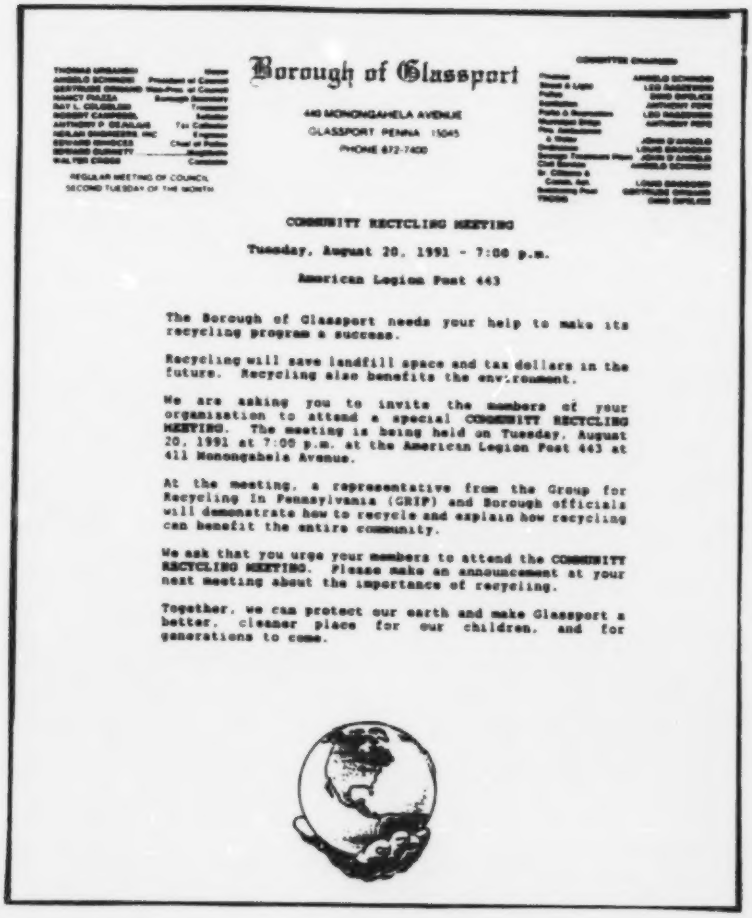
Borough of Glassport

Community Recycling Meeting

Tuesday, August 20, 1991 — 7:00 p.m.
American Legion Post 443

FIGURE 1. RESIDENTIAL NOTIFICATION LETTER

All ten of the municipalities previously mentioned chose to send a separate mailing of a notification letter to all of their residents. As illustrated in Figure 1, a three-fold flyer was designed with the notification letter on one side. The other side of the letter, when folded in thirds, included the bulk mailing permit and address label, information about the date and time of the community recycling meeting, and a municipal logo.



Borough of Glassport

440 MONONGAHELA AVENUE
GLASSPORT PENNA 15045
PHONE 672-7400

REGULAR MEETING OF COUNCIL
SECOND TUESDAY OF THE MONTH

COMMUNITY RECYCLING MEETING

Tuesday, August 20, 1991 - 7:00 p.m.

American Legion Post 443

The Borough of Glassport needs your help to make its recycling program a success.

Recycling will save landfill space and tax dollars in the future. Recycling also benefits the environment.

We are asking you to invite the members of your organization to attend a special COMMUNITY RECYCLING MEETING. The meeting is being held on Tuesday, August 20, 1991 at 7:00 p.m. at the American Legion Post 443 at 411 Monongahela Avenue.

At the meeting, a representative from the Group for Recycling In Pennsylvania (GRIP) and Borough officials will demonstrate how to recycle and explain how recycling can benefit the entire community.

We ask that you urge your members to attend the COMMUNITY RECYCLING MEETING. Please make an announcement at your next meeting about the importance of recycling.

Together, we can protect our earth and make Glassport a better, cleaner place for our children, and for generations to come.

FIGURE 2. NOTICE FOR COMMUNITY RECYCLING MEETING

HOLDING A PUBLIC MEETING

The following six communities chose to hold a public meeting: Elizabeth Township, Glassport Borough, the City of McKeesport, Rostraver Township, Swissvale Borough, and West Mifflin Borough. The other four municipalities chose not to hold a public meeting: Mt. Pleasant Township, Brighton Township, Indiana Township, and Wilkinsburg Borough.

The six communities that held a public meeting advertised the community recycling meeting in the notification letter. This way of notifying the public about the community recycling meeting proved to be quite effective. Each resident and business owner was personally invited to the public meeting. GRIP sent a press release to the local newspaper at least two weeks prior to the public meeting. As illustrated in Figure 2, a notice was also sent to local community organizations and churches, asking them to send a representative to the community recycling meeting who could then take the information back to their group.

Follow-up telephone calls were made by GRIP staff to the community groups and churches two weeks prior to the public meeting, asking if a representative would be coming to the meeting. We asked group members to announce the date and time of the public meeting at their next gathering and to stress the importance of participating in the recycling program. These methods of advertising brought good results. There was a turn-out of at least 250 to 500 people at each of the six community recycling meetings, relative to the population of the community.

The meeting included information about why recycling was being made mandatory in Pennsylvania, requirements of the recycling ordinance, a demonstration on how to prepare the material that each municipality chose to recycle, a video called **THE CIRCLE OF GLASS**, describing how glass is recycled, and a question and answer period.

All of the public meetings were lively. Many questions were asked, complaints were made, and problems were addressed. Many people were concerned about how much the recycling program would cost. Others were afraid their recycling bin would be stolen. Many simply came to learn what was expected of them. Clearly, holding a public meeting was an effective way to educate the public about the coming recycling program and how to best participate.

ESTABLISHING A RECYCLING EDUCATION COMMITTEE

At each of the public meetings, those present were invited to join a Recycling Education Committee for that community. The purpose of the committee was to utilize the energy and commitment of local residents to increase participation in the recycling program. Ten to fifteen residents joined the recycling education committee in each community. GRIP then provided additional training to enable committee members to go out into the community and speak about the recycling program effectively.

PREPARE EDUCATIONAL MATERIALS FOR DISTRIBUTION

Effective educational materials are a vital ingredient to a successful recycling program. GRIP recommends designing materials that are simple, easy to read, and have a consistent message. The following education materials were prepared for distribution in an envelope with the recycling bins:

> Envelope for Education Materials - A 9 by 12 inch envelope with the message "Important - Please Open And Read Immediately." We felt that giving the education materials with the recycling bins, in an envelope, added to the success of the education program. It stress the importance of reading the information, and gave the resident a place to keep the information for reference once the recycling program began. (See Appendix A).

Recycling Brochure - Single sheet of paper folded to 5 1/2 by 11 inches featuring the name of the community on a picture of their recycling bin containing materials selected for recycling. Inside the brochure is a checklist of reasons for working together to recycle along with specific information on how recycling saves landfill space, saves energy, and conserves natural resources. An appeal is made to show pride in the community by recycling and helping to pick up litter to keep the community clean. (See Appendix B).

How to Prepare the Materials - This educational piece begins with "Recycling Is Easy!" Directions are given for either source separation or coommingling materials, depending on the method selected by the municipality. Instructions are given on how to prepare the materials to be recycled. (See Appendix C).

Collection Calendar - Perhaps the most important of the education materials. All of the communities chose to collect the recyclables on the same day as the garbage collection. The number of times per month varied. Recycling collection weeks were indicated on the calendar in colored print. (See Appencix D).

Backyard Composting Flyer - Composting is the oldest method of recovering resources through recycling. The flyer gave simple instructions on how to compost organic materials such as leaves, grass, straw, and vegetable scraps from the kitchen in a backyard compost pile. (See Appendix E).

Letter to the Residents - A simple letter to the residents was included with the education materials. The letter again explained the requirements of the recycling ordinance, stressed the importance reading all information carefully, and following instructions. (See Appendix F).

DELIVERY OR PICK-UP OF THE RECYCLING BINS

Another education tool is the purchase and distribution of recycling bins for residences. Distribution of the bins began in the fall of 1990 as the municipalities went on line with curbside recycling. Eight of the ten communities GRIP assisted chose to deliver the recycling bin or bins to their residents: Brighton Township, Indiana Township, Mt. Pleasant Township, McKeesport, Rostraver, Swissvale, West Mifflin and Wilkinsburg. Elizabeth Township and Glassport asked residents to pick up their bins on designated days. Information on the delivery or pick-up of the bins was included in the notification letter. Press releases were sent to local newspapers. Some municipalities utilized extensive newspaper advertisements.

PRESENT SCHOOL EDUCATION PROGRAM

GRIP's school education program originated in 1988 through a grant from the Laurel Foundation. It was our belief that recycling education in the schools would increase recycling behavior at home. To test our theory, we developed a forty-five minute program designed to be presented to children in grades K through 12 in small groups of no more than sixty to seventy-five students. Schools were selected for presentations in a northern section of Allegheny County that had easy access to a local buy-buck center, Allegheny Recycling. The success of the school program was measured by the increase in volume of materials recycled at the Allegheny Recycling after the presentations were made.

A recent education project funded by the California Department of Conservation's Division of Recycling, the Southwest Regional Laboratory (SWRL), supported the theory that recycling education in the schools increases recycling behavior at home. During the 1989-1990 school year more than 148,000 students from California's most populous counties participated in a two-week recycling education program. Almost 5,000 teachers in 232 public and private school used the curriculum materials by SWRL for children in kindergarten through sixth grades.

Teachers in 95 percent of the participating schools collected recyclables as a opportunity to practice what they learned. Survey results showed that most students and their families recycled more as a result of the curriculum. Eighty percent of the parents surveyed said their child recycled more, and 70 percent said their families are now recycling more.

For the fall of 1990, GRIP revised its school education program to include specific information about materials selected to be recycled in each municipal contract. Funding for the school programs was available from ninety percent reimbursable grants to municipalities from the Pennsylvania Department of Environmental Resources for education and equipment for recycling programs.

GRIP hired a part-time education director and three part-time school presenters and completed school presentations to 41,000 students in thirteen school districts. Our experience during the last year has shown that student participation helped to increase the success rate of the municipal recycling programs we assisted by getting the whole family involved. Through classroom discussion, demonstration, and audio-visual support, through our school program **Recycling - Preserving the Earth**, students were taught effective methods of preserving our planet's natural resources and energy supplies. As a result, students had an opportunity to gain valuable insight on how they affect the world in which they live. The kind of world we are leaving for our children depends on choices we made daily. We all need to make a commitment to recycle and shop with the safety of the earth in mind. Together we can make a real and lasting difference.

At work, at home, and at play, whether shopping for basic necessities, taking a vacation, or cleaning the house, the choices we make are a never-ending series of votes for or against the environment. In the fall of 1990, GRIP received a telephone call from David Gerber, a producer at the local public television station, WQED. A show that WQED had produced in April, close to Earth Day, had featured a short segment on environmental shopping. So much viewer response had resulted from that segment that WQED wanted to produce an hour program devoted to the topic of environmental shopping. After much collaboration, "A Practical Guide To Environmental Shopping" was produced by WQED in association with the Pennsylvania Resources Council, Clean Water Action, the Earth Day '90 Coalition, and GRIP.

The show was taped live in a Giant Eagle supermarket. A pair of volunteer shoppers, armed with information and lists travel through the aisles of the supermarket, facing decisions at every turn. Guest experts from the assists organizations previously mentioned offered advice on which products and what types of packaging posed the least threat to the environment, and why. The show introduced the five R's each of us can practice: Reduce, Reuse, Recycle, Reject, and React. The program aired statewide on PBS stations Monday, November 5 at 8 p.m.

CONCLUSION

A pubic information and education program is one of the required elements for an acceptable municipal recycling program under PA Act 101. While many people are now aware of recycling, very few have any real understanding of what recycling involves or why recycling is necessary. The public education strategy is critical to the success of the recycling program.

Recycling must, therefore, be presented to the public in a way that will make it as convenient and appealing as possible. The public must be informed and educated about why recycling is necessary and how benefits are achieved by recycling. Public perception and expectations about recycling and its benefits will directly influence public participation rates and program success.

Public education and promotion programs must initially be designed to accomplish two goals. The first goal is to show the public how they will benefit from participating in the recycling program. The second goal of the public education program is clearly describe and inform the public of the procedures that they must follow to participate in the program. Good citizenship and community pride may also be emphasized in the public education program to encourage participation. Once the recycling program is started and in operation, the goal of the public education program should then be to focus on the benefits achieved by the program and to keep the public informed about the progress and results of the program.

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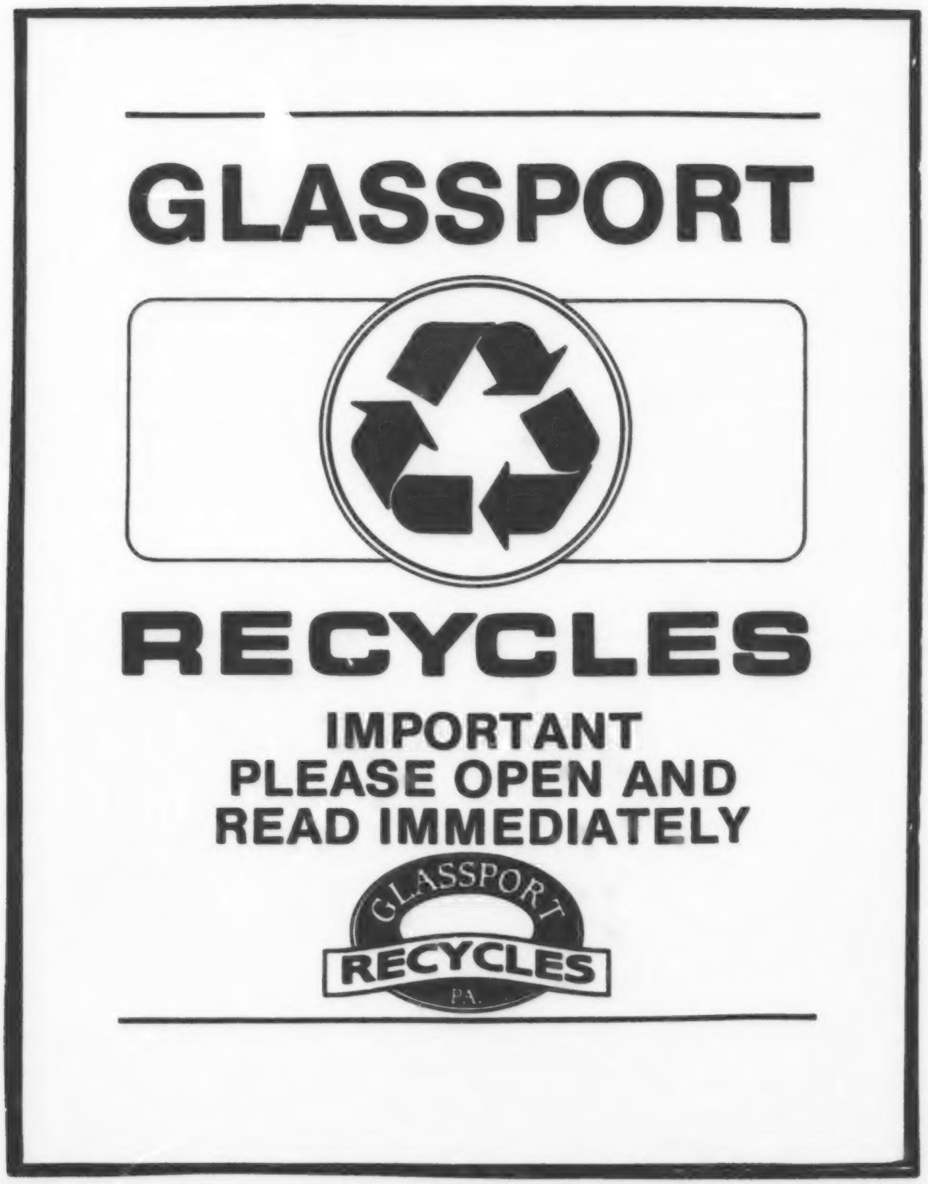
Appendix A



GLASSPORT

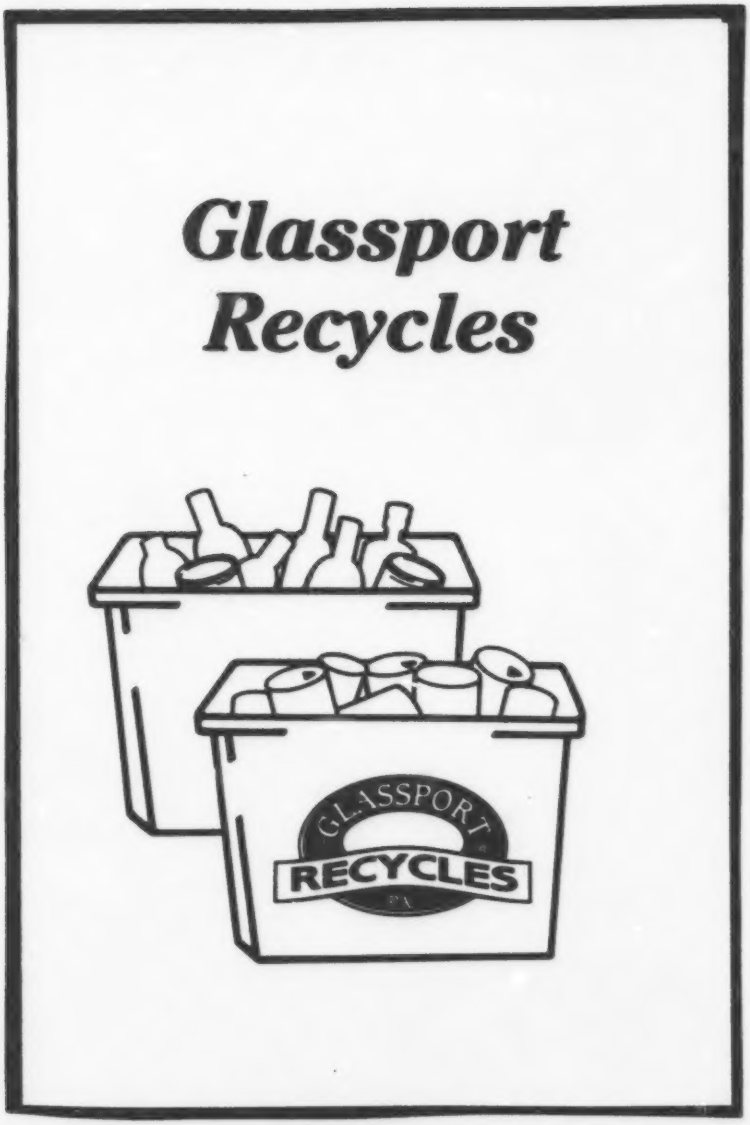
RECYCLES

IMPORTANT
PLEASE OPEN AND
READ IMMEDIATELY

GLASSPORT
RECYCLES
PA.

ENVELOPE FOR EDUCATION MATERIALS

Appendix B

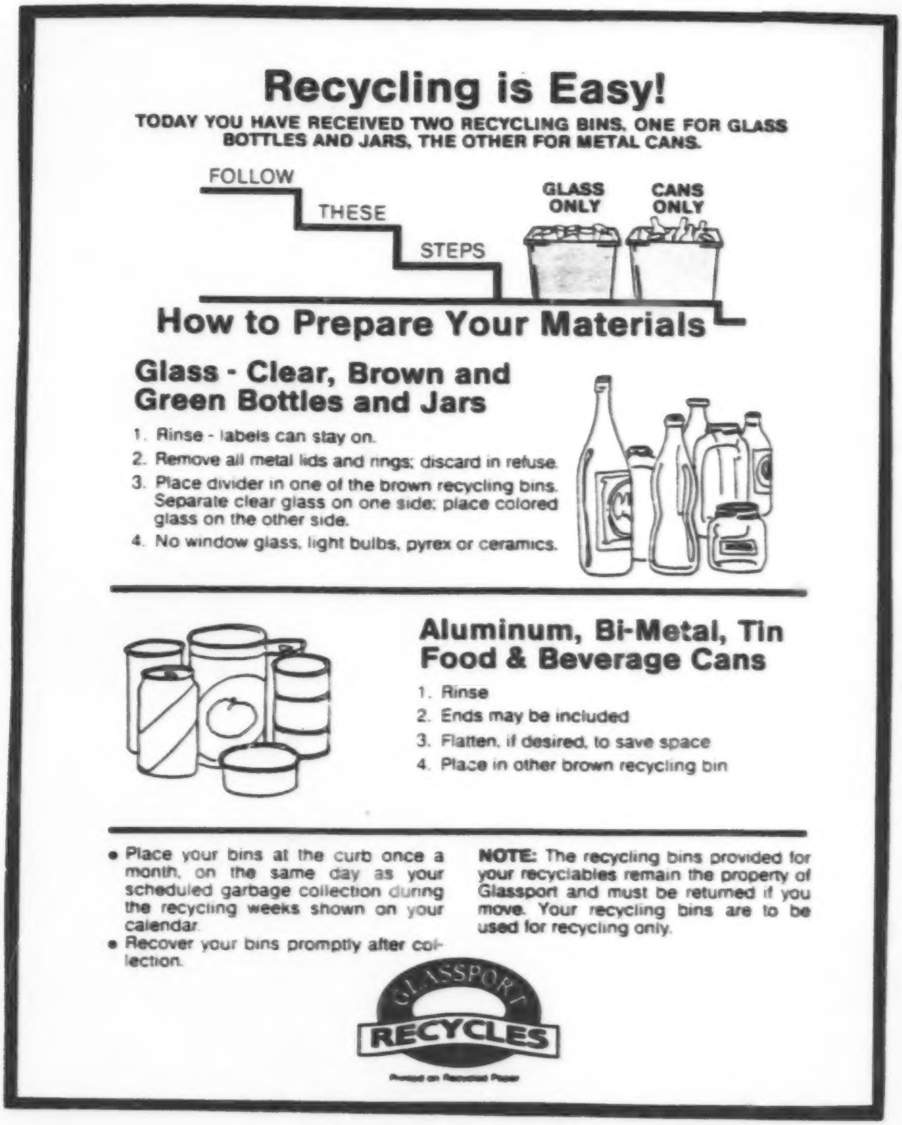


Glassport
Recycles

GLASSPORT
RECYCLES
PA

RECYCLING BROCHURE

Appendix C



Recycling is Easy!

TODAY YOU HAVE RECEIVED TWO RECYCLING BINS, ONE FOR GLASS BOTTLES AND JARS, THE OTHER FOR METAL CANS.

FOLLOW THESE STEPS

GLASS ONLY

CANS ONLY

How to Prepare Your Materials

Glass - Clear, Brown and Green Bottles and Jars

1. Rinse - labels can stay on.
2. Remove all metal lids and rings; discard in refuse.
3. Place divider in one of the brown recycling bins. Separate clear glass on one side; place colored glass on the other side.
4. No window glass, light bulbs, pyrex or ceramics.

Aluminum, Bi-Metal, Tin Food & Beverage Cans

1. Rinse
2. Ends may be included
3. Flatten, if desired, to save space
4. Place in other brown recycling bin

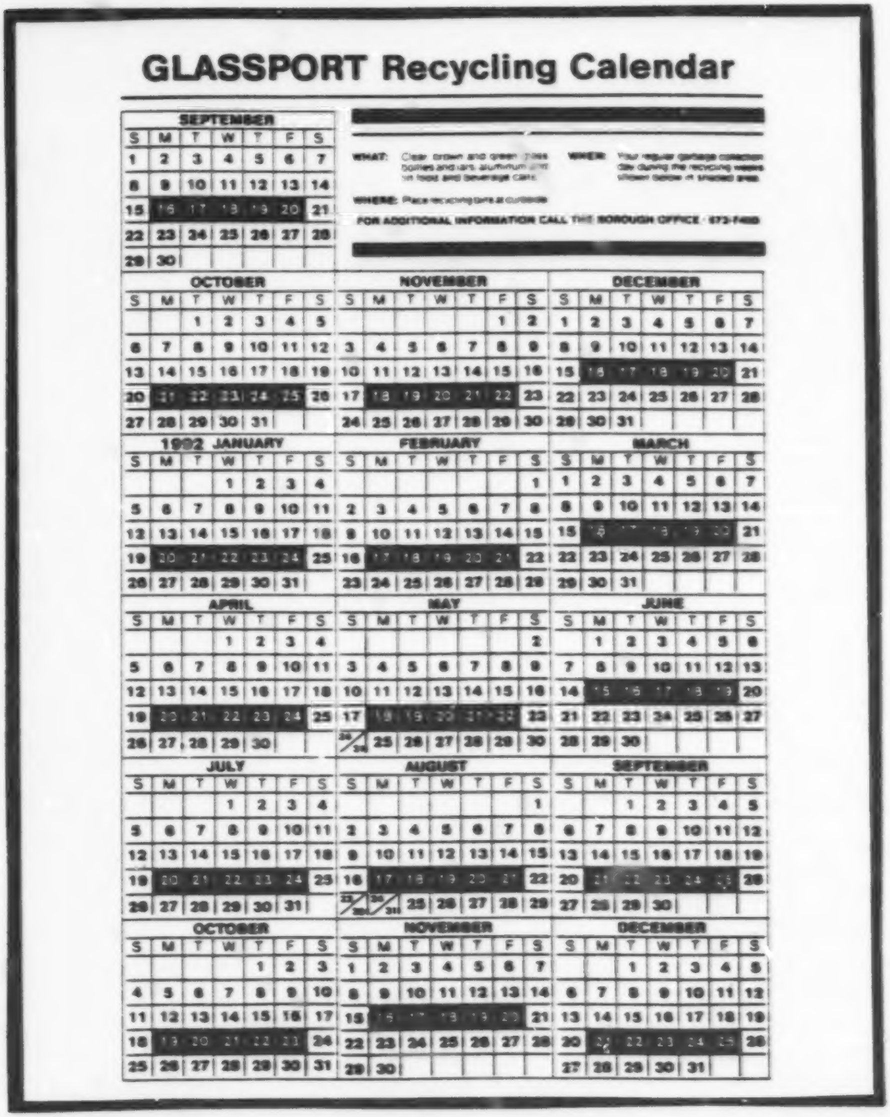
- Place your bins at the curb once a month, on the same day as your scheduled garbage collection during the recycling weeks shown on your calendar.
- Recover your bins promptly after collection.

NOTE: The recycling bins provided for your recyclables remain the property of Glassport and must be returned if you move. Your recycling bins are to be used for recycling only.

GLASSPORT RECYCLES

HOW TO PREPARE THE MATERIALS

Appendix D



GLASSPORT Recycling Calendar

WHAT: Clear, brown and green glass bottles and jars, aluminum and tin food and beverage cans.

WHEN: Your regular garbage collection day during the recycling weeks shown below in shaded area.

WHERE: Place recycling bins at curbside.

FOR ADDITIONAL INFORMATION CALL THE BOROUGH OFFICE · 673-7400

SEPTEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	**16**	**17**	**18**	**19**	**20**	21
22	23	24	25	26	27	28
29	30					

OCTOBER

S	M	T	W	T	F	S
		1	2	3	4	5
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13	14	15	16	17	18	19
20	**21**	**22**	**23**	**24**	**25**	26
27	28	29	30	31		

NOVEMBER

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10	11	12	13	14	15	16
17	**18**	**19**	**20**	**21**	**22**	23
24	25	26	27	28	29	30

DECEMBER

S	M	T	W	T	F	S
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8	9	10	11	12	13	14
15	**16**	**17**	**18**	**19**	**20**	21
22	23	24	25	26	27	28
29	30	31				

1992 JANUARY

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26	27	28	29	30	31	

FEBRUARY

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MARCH

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APRIL

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JUNE

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28	29	30				

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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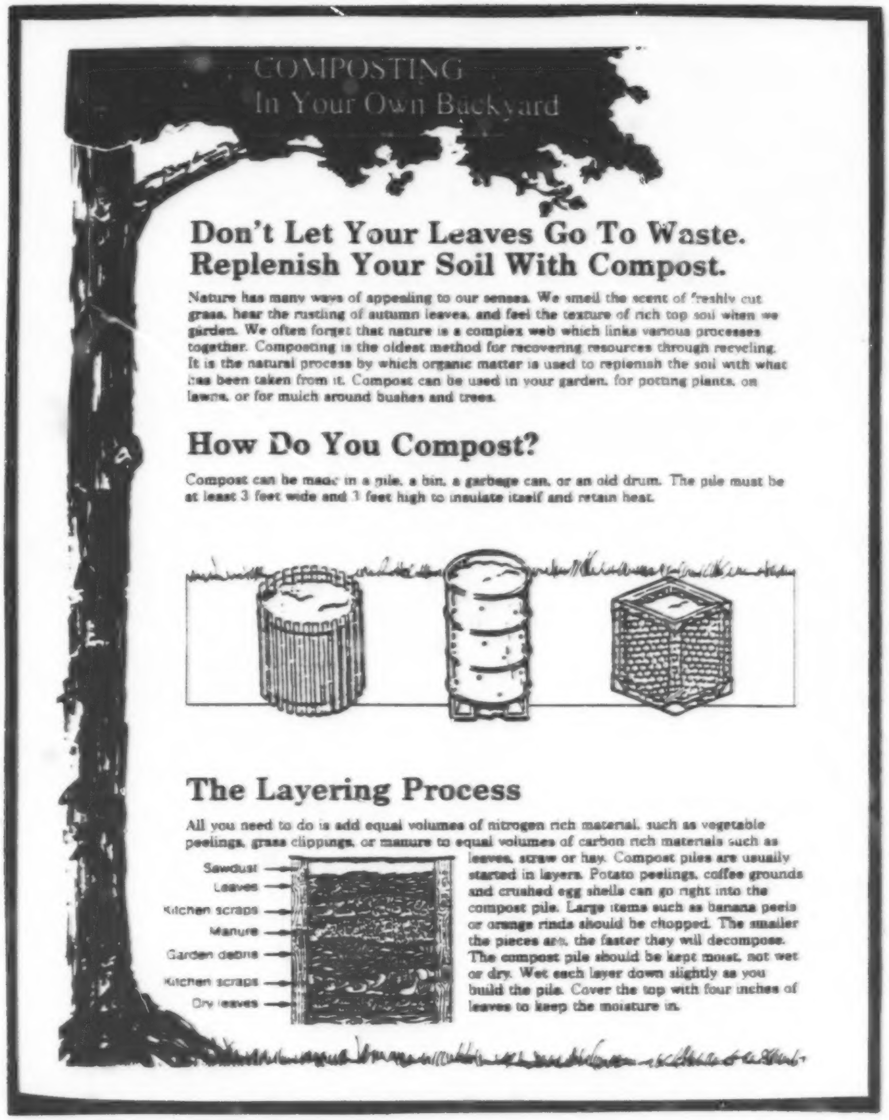
27	28	29	30	31		

COLLECTION CALENDAR

Appendix E



COMPOSTING
In Your Own Backyard

Don't Let Your Leaves Go To Waste. Replenish Your Soil With Compost.

Nature has many ways of appealing to our senses. We smell the scent of freshly cut grass, hear the rustling of autumn leaves, and feel the texture of rich top soil when we garden. We often forget that nature is a complex web which links various processes together. Composting is the oldest method for recovering resources through recycling. It is the natural process by which organic matter is used to replenish the soil with what has been taken from it. Compost can be used in your garden, for potting plants, on lawns, or for mulch around bushes and trees.

How Do You Compost?

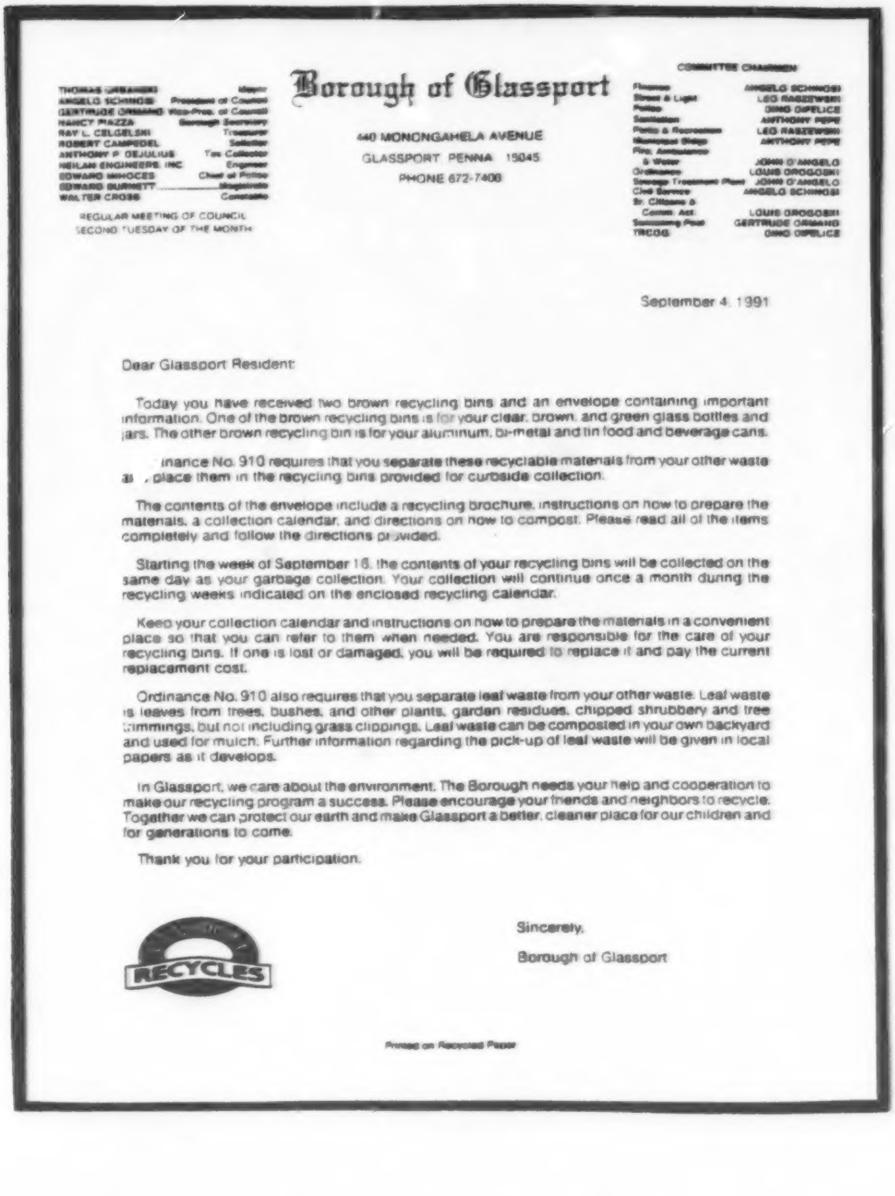
Compost can be made in a pile, a bin, a garbage can, or an old drum. The pile must be at least 3 feet wide and 3 feet high to insulate itself and retain heat.

The Layering Process

All you need to do is add equal volumes of nitrogen rich material, such as vegetable peelings, grass clippings, or manure to equal volumes of carbon rich materials such as leaves, straw or hay. Compost piles are usually started in layers. Potato peelings, coffee grounds and crushed egg shells can go right into the compost pile. Large items such as banana peels or orange rinds should be chopped. The smaller the pieces are, the faster they will decompose. The compost pile should be kept moist, not wet or dry. Wet each layer down slightly as you build the pile. Cover the top with four inches of leaves to keep the moisture in.

BACKYARD COMPOSTING FLYER

Appendix F



THOMAS URBANSKI	Mayor
ANGELO SCHINOSI	President of Council
GERTRUDE ORMAND	Vice-Pres. of Council
NANCY PIAZZA	Borough Secretary
RAY L. CELGELSKI	Treasurer
ROBERT CAMPEDEL	Solicitor
ANTHONY P. DEJULIUS	Tax Collector
NEILAN ENGINEERS, INC	Engineer
EDWARD MIHOCES	Chief of Police
EDWARD BURNETT	Magistrate
WALTER CROSS	Constable

REGULAR MEETING OF COUNCIL
SECOND TUESDAY OF THE MONTH

Borough of Glassport

440 MONONGAHELA AVENUE
GLASSPORT, PENNA. 15045
PHONE 672-7400

COMMITTEE CHAIRMEN

Finance	ANGELO SCHINOSI
Street & Light	LEO RASZEWSKI
Police	DINO DIFELICE
Sanitation	ANTHONY PEPE
Parks & Recreation	LEO RASZEWSKI
Municipal Bldgs	ANTHONY PEPE
Fire, Ambulance & Water	JOHN D'ANGELO
Ordinance	LOUIS DROGOSKI
Sewage Treatment Plant	JOHN D'ANGELO
Civil Service	ANGELO SCHINOSI
Sr. Citizens & Comm. Act.	LOUIS DROGOSKI
Swimming Pool	GERTRUDE ORMAND
TRCOG	DINO DIFELICE

September 4, 1991

Dear Glassport Resident:

Today you have received two brown recycling bins and an envelope containing important information. One of the brown recycling bins is for your clear, brown, and green glass bottles and jars. The other brown recycling bin is for your aluminum, bi-metal and tin food and beverage cans.

Ordinance No. 910 requires that you separate these recyclable materials from your other waste and place them in the recycling bins provided for curbside collection.

The contents of the envelope include a recycling brochure, instructions on how to prepare the materials, a collection calendar, and directions on how to compost. Please read all of the items completely and follow the directions provided.

Starting the week of September 16, the contents of your recycling bins will be collected on the same day as your garbage collection. Your collection will continue once a month during the recycling weeks indicated on the enclosed recycling calendar.

Keep your collection calendar and instructions on how to prepare the materials in a convenient place so that you can refer to them when needed. You are responsible for the care of your recycling bins. If one is lost or damaged, you will be required to replace it and pay the current replacement cost.

Ordinance No. 910 also requires that you separate leaf waste from your other waste. Leaf waste is leaves from trees, bushes, and other plants, garden residues, chipped shrubbery and tree trimmings, but not including grass clippings. Leaf waste can be composted in your own backyard and used for mulch. Further information regarding the pick-up of leaf waste will be given in local papers as it develops.

In Glassport, we care about the environment. The Borough needs your help and cooperation to make our recycling program a success. Please encourage your friends and neighbors to recycle. Together we can protect our earth and make Glassport a better, cleaner place for our children and for generations to come.

Thank you for your participation.

RECYCLES

Sincerely,

Borough of Glassport

Printed on Recycled Paper

LETTER TO THE RESIDENTS

Setting Priorities for Negotiating Waste Facility Siting and Impact Management Agreements

(L'établissement des priorités de négociation concernant l'emplacement d'une installation de gestion des déchets et les accords portant sur la gestion des impacts)

Chris Zeiss
University of Alberta
Edmonton, Alberta

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

The Role of Community Based Programming in Solid Waste Planning

David E. Baird

The topic I am about to expound upon, **the Role of Community based Programming in Solid Waste Planning,** is a subject of long term concern. I can remember the role the activists of the 1960's played in trying to effect a change in the abuse they saw happening to our world. Rachel Carson's book, 'Silent Spring', touched off a quiet storm. Have we taken heed yet? Perhaps the youth of the sixties were fortunate in that the expanding economy which was causing the problems of their concern, also provided the ease and surety of lifestyle from which to base their protests. Although there were the basic back to the land types, many protested from the safety net of a more affluent, expanding society and lifestyle. Many were the 'Baby Boomers' crying out from the Ivory Towers of their universities.

There was some recognition of the forthcoming waste problems, albeit mainly as a corporate motive to avoid having to deal with beverage container legislation. **Keep America Beautiful, Inc.** was born of as a product of a number of corporations recognizing that litter (solid waste) was a problem. A problem that had a solution in public education. The corporate motivation to establish an organization to provide the public education, was the visibility problem of the waste (litter). This visibility had politicians talking beverage container legislation, which would invariably cost these corporations a lot of money. What was developed was an organization through which they could appease their corporate consciousness and establish a good corporate image. Fortunately, the symptom of their concern had the same roots as the more general lack of societal concern for the waste being generated in the name of convenience.

The **KAB System** was developed, based on research done on human behaviour in the context of solid waste. The programs resulting from this research have been adopted and adapted in a number of the more affluent nations of the world. The lesser developed nations don't have the same problems of visible waste, because most waste is a resource for someone else! Only now are we re-discovering the virtues of this on a mass level.

The message of environmental concern got lost in the political turmoil of the early 1970's. Any one remember Vietnam? By now, many of the radicals of the 1960's and early 1970's had become the consumptive Yuppies of the late 1970's and 1980's. The baby boomers grew up and left their ivory towers! With the rapidly diminishing landfill capacity, our consumptive habits have come back to haunt us. Now it is fashionable or Politically Correct to be environmentally concerned. The habits are the same as those that spawned the litter problem. The KAB System was easily adapted to deal with the educational aspects addressing the behaviors that produced the problem in the first place. One might say that the early KAB message was **Redirect,** send waste to landfills. The current message is the now familiar 3R hierarchy, **Reduce, Reuse and Recycle.** The method is grass roots involvement in effecting these principles. People and Business working in concert, pushing Government for solutions; showing the politicians what can be done and how in many cases.

Having just been hired by the City of Saint John where my area of responsibility included dealing with street sweeping and litter containers, I began to look at alternatives to simply cleaning up after people. The City was prepared to be supportive of the creation of an organization whose mandate was litter management. After considerable investigation, it became apparent that the KAB System was the most comprehensive and widely applicable program. The fact that the KAB System was used internationally and had been demonstrated to work in a Canadian context, made it the program of choice. Mississauga, Ontario, has been affiliated with KAB for over ten years. (In fact, since our joining KAB, St. John's, Newfoundland has joined, and Winnipeg, Manitoba, has undergone training by KAB) Further, the level of interaction and information sharing that was exhibited at the KAB Annual Meeting underlined the value in aligning with such an organization.

In fact, the first project, which was undertaken prior to the actual formalization of our group, was as a result of an idea acquired at the KAB Annual Meeting in 1989. In three weeks we put together a Christmas Tree Mulch program that garnered international media exposure, and in 1990, received the first **International Recycling Award** given by Keep America Beautiful. More on that later.

Keep Saint John Beautiful, Inc. was created in early 1990 by a group of individuals of diverse background and interests. The plant manger of a major brewery, a school principal, the manager of a public relations firm and myself. As the board of directors was developed, more individuals from throughout the community became involved.

Let me provide some background with respect to Saint John and its' position on solid waste. The City of Saint John operates the largest landfill in the province of New Brunswick. It is called a Sanitary Landfill, but its' technology is state of art as it existed prior to 1978. There is no liner; there are virtually no bans on materials accepted; tipping fees are nominal, only recently having risen above the $10. per ton level. It is now full and the municipality is seeking an expansion for 3 to 4 years on the present permits. Still, there are no recycling collection systems organized by the municipality; nor is the municipality engaged in waste reduction education, other than the token distribution of 100 home composter units. Even a community wide mobile depot system patterned after Howard Co., Maryland's **'Sort with MORT'** program was not supportable, even at a projected operational cost of only $1.50 per household per year!

Keep Saint John Beautiful, Inc. has attempted to show the residents that there are problems and there are solutions which they can help effect. Every year tons of Christmas Trees were either landfilled or burned. Having been shown a method used in Kingsport, Tennessee, we developed a project that identified what the waste was, provided an alternative, that through a festive public participatory event, produced an end product that was to serve a further useful purpose. Through the help of volunteers, christmas trees were converted to chips. In 1990, the beneficiary of the chips was the local exotic animal zoo. In 1991, excess chips, beyond the needs of the zoo, were made available on the site, for the public to take as they required. One lady and her elderly mother managed to shovel seven loads (about 14 cubic yards!) into her pickup truck during the course of the day!

In 1990, 5000 trees were chipped and in 1991, 6500 trees were processed. Keep in mind, the project was a public participatory, volunteer staffed event, at which about 25 to 30 per cent of the natural trees sold in the community were brought in to the mulching event. To further develop the public exposure to the event, a deposit system was designed. A number of major tree vendors purchased from us, tree shaped tags for one dollar. The tags were printed with instructions on the installation and care of a christmas tree tree. The tag also described where to take the tree to be chipped, and get the one dollar refund.

To underline the importance of the KAB link, we learned about tree mulching from an event conducted in Kingsport. We returned to the next KAB annual meeting to present how our event worked. Kingsport has subsequently called us for advice on modifying their tree mulching event. It is this sort of information sharing that makes the KAB tie important.

Upon the success of the first Christmas Tree mulch, and learning of the 'yellow layers' reported by Dr. Rathje in his digs, we designed a similar event to collect telephone directories. The key to marketing these events was the presentation of a closed loop package to the media, whereby the public knew in advance, how the commodity to be recycled would ultimately be used. In 1990, the 11,000 telephone books collected (10% of those issued) went to a mill that produces pulp that is used in part to manufacture egg cartons. Endorsement by the Egg Marketing Board as a sponsor helped define the project. In 1991, the 18,000 directories collected, were used by a local company that produces bedding for dairy cattle and other farm animals. Cooperation on the part of NB Tel allowed that we could have a printed insert, placed in every directory, encouraging residents to bring their old directories to one of the event's locations.

Prior to these events, as we developed them, little thought and exposure had been given to the nature of these two commodities as a mass waste problem in our community. There had been a small cry for a 'blue box' program, which the City had rejected out of excessive cost. We have attempted to show that there are alternatives in which the residents themselves can partake.

For **Earth Day, 1990**, with the assistance of First Brands, we arranged for the distribution of 30,000 garbage bags as an insert the evening newspaper. As a radio station promotion, we encouraged an Earth Day clean up for the community. Prizes, including an all expense paid trip for two to Toronto, enticed residents to bring full bags to one of several depots. A total of 24 tons of material was collected in this manner. In a Cost:Benefit ratio calculation, we showed that for every dollar of City donated equipment time used, which does not include labour, a benefit of $17. in service value was achieved.

In 1991, we modified the Earth Day promotion to include the separation of recyclable goods. The amount of garbage collected at the depots, was reduced to 9 tons.

However, a measure of the day's success can be seen in the following summary:

20 tons of newsprint,
3.5 tons of clear glass,
1.5 tons of green glass,
500 pounds of brown glass,
2300 pounds of steel cans,
1800 pounds of aluminum cans,
1000 pounds of cardboard and
536 litres of used motor oil

were collected as separate commodities over a 4 hour period.

We have, in the community, a private company that accepts recyclables, which they prepare and market. They do not buy recyclables. They depend on the contributions of citizens concerned about the global garbage problem. We have attempted to bring this public desire to the attention of the politicians, both locally and provincially. They have heartily embraced our actions as being positive and proactive. Yet, little else is done, on the basis of cost and perhaps misplaced priorities. There was, after all, the mobile depot system we developed that would have cost little, yet had major political good will associated with it.

There is a process on going in New Brunswick to regionalize solid waste management. The creation of Keep Saint John Beautiful, Inc., coincided with the creation of the Fundy Regional Solid Waste Provisional Committee (now called Fundy Solid Waste Action Team or Fundy SWAT), the regional group that encompasses Saint John and outlying areas. At this time, Fundy SWAT is almost two years into a five year public consultation process, assessment of alternatives, and development of a solid waste management system. What we, Keep Saint John Beautiful, Inc., have been doing and will continue to do as a community based organization, is to work to educate the public and enlist public involvement, in solving some of our solid waste problems

David E. Baird, B.A., B.Sc., P.Geol.

Public Opinion and Non-hazardous Waste

(L'opinion publique et les déchets non dangereux)

John Jackson
Ontario Toxic Waste Coalition
Kitchener, Ontario

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

COMPOSTING - AS A VIABLE SOLUTION TO MUNICIPAL SOLID WASTE MANAGEMENT AND SCOPE FOR STANDARDS.

BY KEN L. DE, 3R Enviro Associates
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ABSTRACT

Composting is being accepted by increasing number of municipalities as a viable means of minimizing organic solid and leaf wastes from municipal solid waste stream (MSWS). It can divert up to 60% of MSWS from landfill sites, depending on the waste stream composition, thereby reducing landfill requirement. However, success of composting depends on the public perception and acceptance, regulatory agencies and the municipalities.

There is also a lack of national consensus standards (except regulatory guidelines) for a) quality of compost b) composting units - both household and commercial systems.

This paper outlines general scope and utility for such standards and covers regulatory perspectives.

U.S. Environmental Protection Agency (EPA) and Solid Waste Composting Council recognize the vital role that composting plays to address our solid waste problems as a form of recycling.

Background

In Canada, approximately 16 million tonnes of Municipal Solid Waste (MSW) is generated annually. Ontario alone generates about 10 million tonnes of waste annually. About 3 million tons of waste is generated by Greater Toronto Area (GTA). The composition of MSW will vary depending on the location, economic and social patterns, season and most importantly the extent of source reduction, recycling, and reuse. However, the residential waste may constitute as much as 60% (total) of food wastes, yard waste and other biodegradable components which are the prime raw materials for composting practices. Therefore, composting can reduce the waste stream by up to 60% and at the same time, can produce a valuable soil additive from material which would otherwise be wasted. There is a large market for compost that consists of nurseries, garden centres, farmers, landscapers, contractors, sod and turf farms, golf courses, greenhouses, land reclamation projects, municipal parks and playing fields.

With the declining capacity and number of landfills both in U.S. and Canada (one-third of the 6000 operating landfills in the U.S. is expected to close by 1995 and in the Greater Toronto Area the landfill capacity is expected to last until 1994), the process of composting food and yard wastes will play an increasingly important role in Municipal Solid Waste Management. The present policy of the

Ontario Ministry of the Environment (MOE) virtually eliminated incineration, energy from waste (EFW), refuse derived fuels (RDF) and transporting of garbage to Northern Ontario (Kirkland Lake). Increased emphasis is placed on 3R - reduction, recycle and reuse, in order to achieve 25% waste reduction by the year 1992 and 50% by the year 2000. EPA, Municipalities and U.S. Composting Council are all promoting composting as a significant step to reduce the amount of waste destined for landfilling, thereby saving valuable landfill capacity for the years to come.

According to a recent Environment Canada Report [1] Canadian Municipalities are utilizing increasing combinations of recycling and composting as means of Solid Waste Management as opposed to only landfilling (35% landfilling only). However, the success of composting for MSW reduction depends on several factors such as:
a) waste separation; b) compost quality; c) acceptance of compost as soil additive and various other uses; d) perception and education of users; e) finally and most importantly market demand. Depending on these factors the compost might end up in landfill again [2].

Presently, there is no national standard for composting other than regulatory guidelines. A preliminary telephone survey was conducted to determine the scope and viability of developing such standards. A task force (TF) on solid waste minimization (SWM) at CSA supported an idea of developing standards on composting.

A recent meeting with the Ontario Ministry of the Environment (MOE) and Metro Toronto indicated further support to develop standards on composting.

Objectives

The objective of this paper is to outline the scope and viability for national standards on:

- Quality of Compost for marketability;
- Testing Methods (Aerobic/Anaerobic) for compost;
- Performance Standards of Household/Backyard composters;
- Performance Standards of Centralized Composters;
- Best Composting Practices.

Definitions

The definitions of "composting", "compost", "aerobic/anaerobic composting" and "composting units" are relevant to mention as there is difference in wording, although they mean the same in principle.

According to ECP (Environmental Choice Program) guideline ECP-15-90 [3] composting means the biological decomposition of organic matter by soil organisms into compost; the compost is defined as a homogeneous and friable mixture primarily composed of stabilized (no longer decaying) matter. The "composting container for residential waste" means a container which allows for the controlled biological decomposition of organic yard and kitchen wastes. According to Dr. Ramani Narayan, ASTM D20.96 committee chairman and a prominent scientist, composting is defined as "accelerated degradation of heterogeneous organic matter by a mixed microbial population in a moist warm, aerobic environment under controlled conditions". "Composting" has been used interchangeably with "biocycling". He spoke about composting - a solution to sustainability of the agricultural system [4] and Integrated Waste management approach by EPA.

Documents Review for Standardization

A literature survey indicates that, although there are numerous scientific articles and guidelines available, there are no national consensus standards available in the U.S. or Canada on this subject. Recently M.O.E. (Ontario Ministry of the Environment) published a draft guideline [5] for the production and use of aerobic compost in Ontario with an objective to "ensure that composting projects and compost use are managed with due regard to process conditions and chemical and physical characteristics, to prevent contamination of the environment". This guideline does not apply to backyard composting by householders and will consider compost as a "processed organic waste" per Regulation 309, if it fails to meet this guideline. Therefore, this guideline addresses the issues of compost and composting from waste management point of view only. Composting - a literature study, 1989 [6] provides an excellent source of generic information on composting, processes, technologies, list of North American and International facilities and policies, regulations and guidelines for composting operations. Other provinces apply existing regulations for land application of sewage sludge while many other provinces do not have any applicable regulation [6].

In the U.S., EPA has been active in formulating policies and guidelines for compost operation. However, it is the responsibility of state and municipal governments to develop regulation for composting of Municipal Solid Wastes and yard wastes. Florida, Maryland, New Jersey, New York, Minnesota and Wisconsin already ban yard wastes from landfills and the list is expected to grow. Japan, the European Communities particularly Netherlands, Federal Republic of Germany, France, Italy, Switzerland and the United Kingdom (UK) have taken a leading role in using composting as a solution to waste management. CEC (Commission of the European Communities) is developing policies and guidelines for compost operations in Europe.

Composting has been reported to be an applicable method of waste conversion for a) sewage sludge b) dead poultry [7] c) livestock manures according to Agriculture Canada Scientist Dr. Sukhu Mathur at Land Resource Research Centre (LRRC) in Ottawa d) wood waste into garden and agricultural compost (per

Wood Conversion Inc. in Brampton) e) fish wastes from the fish processing industries.

The new composting process proposed by LRRC is called passively aerated windrow system and involves putting 6-9 inch base of peat moss or compost material in 3x2 metre windrows on a gravel base. Once the base is in place, 3-metre long perforated ABS pipes, 10 cm in diameter, are placed across the material 12 to 18 inches apart. Solid manure waste is then placed on top of the pipes to a height of 3-5 feet depending on how much straw is in the manure. A covering peat moss or compost is put on top of the manure to seal it so odours do not escape and flies are not attracted. The holes in the ABS pipes are face up so warm air entering the pipe from the sides will move upward and sideways into the compost at a temperature of 55°C, providing an ideal combination of aeration and temperature for micro-organism to break down the manure quickly, and to produce a top quality compost in 10 to 12 weeks.

Although the commercial composting practices have been covered more extensively in literature than home composting, it is the home-composting that will also play an important role in MSW reduction. In Ontario, the Recycling Council of Ontario (RCO) has launched "Compost Ontario" to promote home composting and to educate and provide information on home composting.

Currently there are several interest groups in Canada that are active in the areas of composting eg. a) Environmental Sustainability group of Agriculture Policy Branch, Agriculture Canada, Ottawa b) Composting Council of Canada, Public Affairs International, Ottawa c) Composting Management Association (CMA).

Composting Process and MSW

The basic requirements for the composting process are:

a) breakdown of the organic materials in presence of bacteria/micro-organism with reduction in volume and water (moisture) content

b) pathogen reduction/elimination at a temperature of 55°C-60°C for a period of time (3 days in vessel to 15 days in windrow and static pile composting)

c) adequate flow of oxygen/air through the compost pile. Oxygen level is generally maintained above 10% (v/v) (range= 12-18%) in order to produce a stable (non decomposing) quality of compost which meets MOE/ECP guidelines in terms of remaining toxic metals, organic chemicals (PCB) and other physical characteristics.

Table 1 provides a comparison of acceptable quality criteria for compost between ECP, MOE and US guideline.

Note: In the US the compost quality varies from state to state, usage, and source of composting.

TABLE 1 COMPOST QUALITY CRITERIA - A COMPARATIVE STUDY

1. Heavy Metal Concentration (Max) (should not exceed on dry weight basis (mg/kg dry wt)	ECP - Guideline (ECP-23-90) Environment Canada	MOE Guideline (Ontario)	US (see note)
Arsenic (As)	13	10	2-100
Cadmium (Cd)	2.6	3	---
Chromium (Cr)	210	50	1000
Cobalt (Co)	26	25	---
Copper (Cu)	128	60	500-3000
Lead (Pb)	83	150	250-5000
Mercury (Hg)	0.83	0.150	5-10
Molybdenum (Mo)	7	2	10
Nickel (Ni)	32	60	50-1250
Selenium (Se)	2.6	2	---
Zinc (Zn)	315	500	900-10000
2. PCB (mg/kg dry weight Max)	---	0.5	1-10
3. pH	5-8	5.5-8.5	---
4. Organic Matter Content (% of dry weight)	30%	30%	---
5. C/N ratio	---	22	---
6. Particle Size (mm)	<13	<25	<25
7. Moisture Content (%)	<50%	30-55%	---

Figure 1 provides an integrated waste management approach that stresses recycling and composting - EPA's waste management emphasis for MSW.

Scope of Standards

Compost quality for various market segments

The scope of this standard is to establish the quality of compost for its users or target markets by identifying the following characteristics. Currently the limits set by various guidelines (see Table 1) do tend to vary and are not precisely defined for market segments based on the specific use of the compost.

a) Chemical characteristics of the compost such as pH, organic matter content, water content, sodium adsorption ratio, carbon/nitrogen ratio, phosphorous content, salts, heavy metals, PCBs, toxicities, nutrients balance, total organic halides (TOX) etc.

b) Physical characteristics of compost such as colour, particle size, odour, absence or presence of contaminants or clumps etc.

c) Degree of maturity at which compost can be labelled as acceptable for its destined uses and environmental impact.

d) Acceptable levels of inert materials such as glass, shards, scrap metal and plastics etc in municipal solid waste (MSW) stream, as raw input for composting.

e) Biological characteristics of compost (eg. organic matter, pathogen, weed/crop seed).

f) Related Definitions and Terminologies.

Testing Methods for Aerobic Composting and Compost Quality

The scope of this standard is to outline the detailed test methods for aerobic composting, compost products and compost quality.

Note: ECP (Environmental Choice Program) and MOE guidelines do not address test methods for compost quality.

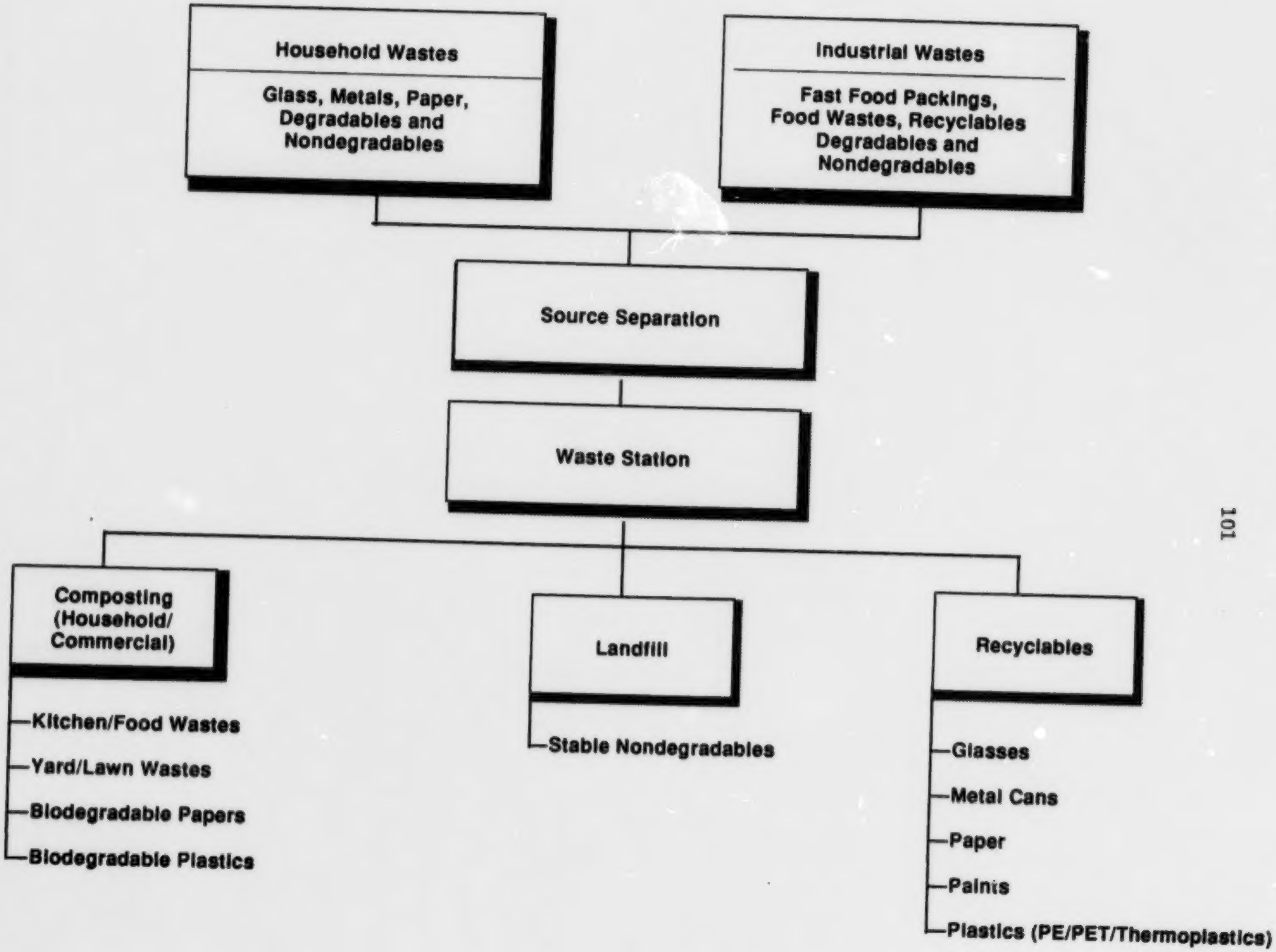

Household Wastes
Glass, Metals, Paper, Degradables and Nondegradables
Industrial Wastes
Fast Food Packings, Food Wastes, Recyclables Degradables and Nondegradables
Source Separation
Waste Station
Composting (Household/ Commercial)
Kitchen/Food Wastes
Yard/Lawn Wastes
Biodegradable Papers
Biodegradable Plastics
Landfill
Stable Nondegradables
Recyclables
Glasses
Metal Cans
Paper
Paints
Plastics (PE/PET/Thermoplastics)

FIGURE 1 MSW FOR COMPOSTING, LANDFILLING AND RECYCLING

Performance Standards for Household and Commercial (Centralized) Composting Systems

The scope of these standards will be to develop, in addition to ECP guidelines, a national standard on acceptance criteria for household composters. This will facilitate municipalities and home compost users to compare and select among a number of home composters and digesters available in the market place, based on a set of uniform criteria.

Table 2 outlines the list of likely standards on composting with their complexity and preference. Since anaerobic composting is not widely used, the testing methods on anaerobic composting is the least priority.

Standards on Best Composting Practices (BCP)

The scope of these standards will be focused on the best (optimum) operating conditions and the quality control parameters for various composting technologies eg.

Technologies:

- Turned Windrows
- Static Pile (forced aeration)
- In-vessel
- Hybrid

Operation and Control Parameters:

- Time requirements
- Temperature requirements
- Moisture requirements
- Structural requirements
- Air (oxygen) requirements
- Nutritional requirements (eg. Carbon (C), Nitrogen (N), Phosphorus (P), Potassium (K), etc.)
- Mixing requirements
- Collection, physical and mechanical separations

TABLE 2 LIST OF LIKELY STANDARDS ON COMPOSTING

Standard Description	Document Complexity	Consultancy Level	# of Meetings	Preference By MOE	METRO
1. Compost Quality/ definitions	7	3	5	H	H
2. Testing Methods for Aerobic Composting	7	5	7	H	H
3. Composting Units (Household)	7	5	7	H	M
4. Best Composting Practices	10	6	8	M	M
5. Composting Units (Municipal/ Centralized)	10	6	8	M	M
6. Testing Methods for Anaerobic Composting	8	6	7	L	L

Document Complexity: 1 (Simple) ________________ 10 (Complex)
Consultancy level: 1 ($ 5 K) ________________ 10 (50 K)

Preference: H - High M - Medium L - Low

Benefits of National Standards on Compost

- No national standard presently exists on composting other than ECP and regulatory/municipal guidelines. These guidelines do not provide any nationally accepted testing methodology and national consensus standard.
- Such standards will assist to regulate uniformity and consistency on compost quality and performance criteria on both household (backyard) and commercial/centralized composting units.
- Such standards will control environmental and health effects during the process of producing the compost and its subsequent use.
- Such standards would establish procedures for collection of compostable organic (food) matter and yard/garden leaves.
- Over 25 Ontario municipalities currently have a home (backyard) composting program. Several large municipalities either have a centralized composting unit in place or on the drawing board in both U.S.A. and Canada. Over 100 solid waste composting facilities are planned for in U.S.A. within the next two to three years. Therefore, the need for the standards on composting is imminent and timely.
- Concepts of composting (Biodegradation or Biocycling) are now being extended to Biodegradable plastics and sewage sludge composting, substantiating further the need for such standards.

CSA and The Environment Program

For more than 70 years, the Canadian Standards Association (CSA) has been developing product and service standards, guidelines, codes and other documents, as well as providing extensive testing, certification and verification services. CSA is an independent, not-for-profit organization with over 900 staff in offices across Canada, Europe, and the Far East, and over 8000 volunteer experts. To date, CSA has published approximately 1500 standards, guidelines and codes in more than 36 fields of technology, over one third of which have been referenced in legislation. The Association has already more than 35 environmental standards with numerous committees active in the environmental fields.

CSA's current environmental programs include (but not limited to):

- Air Quality;
- Acoustics and Noise Control;
- Waste Management including MSW;
- Environmental Choice Program (ECP);
- Clarification and Verification Services;
- Laboratory Testing;
- Environmental Degradability (of plastics);
- Recycling;
- Qualification Code for Laboratories Analyzing Industrial Waste;

- Emergency Response and Preparedness;
- Transportation of Dangerous Goods (TDG);
- Energy Efficiency and Conservation;
- Nuclear Waste Management;
- Pesticides;
- Health Care/Biomedical Waste;

The other environmental programs under development at CSA include...

- Environmental/Waste Auditing;
- Product Life Cycle Planning and Costing;
- Water Quality;
- Composting; and
- Environmental Education Programs

This list is by no means comprehensive with the continuing participation from the governments, users, producers and the consumers, and the public in general. CSA is dedicated to expand the scope of its environmental endeavours in the 1990s.

Standards Development Methodology

The development of a new standard at CSA is based on a seven phase procedure lasting approximately 18 month on an average. However, the actual duration of a standard development will depend on the complexity , extent of research and review required and the time to resolve any negative votes. The flow diagram (Figure 2) outlines this multi-phase development for a new standard.

Phase 1 involves reviewing the need for a new standard in terms of applicability, interest and resources required to realize its development, and leads to project authorization or rejection.

Phase 2 involves the preparation of a working document (eg. first draft) from several technical committee or subcommittee meetings and their input.

Phase 3-5 involves the refinement of the technical content and development of subsequent drafts, Guideline-F auditing and proapproval editing, leading to an acceptable draft for review and balloting by the Technical Committee (TC) and the Standards Steering Committee (SSC).

Phase 6 involves Due Process Balloting of the preapproved draft. The draft standard after PAE is sent out for letter balloting by the members of the Technical and Steering Committee. Requirement for approval is that a) 50% of the voting membership; b) two-third of votes cast must be affirmative; and c) that all the negatives (disapproval) must be duly addressed and resolved. However, a negative vote must be accompanied with an appropriate explanation for disapproval, without which, a negative vote is considered non-persuasive (unacceptable).

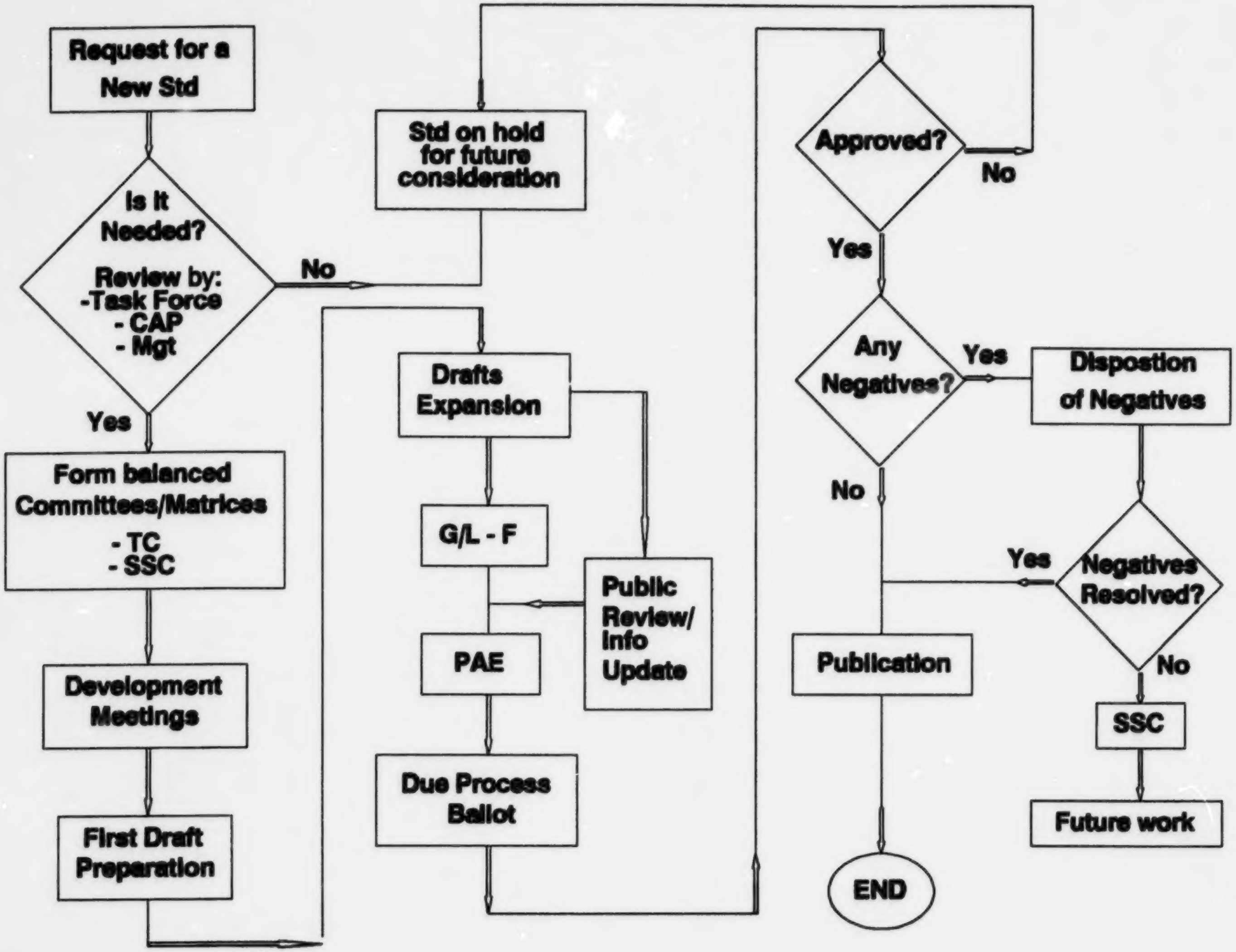
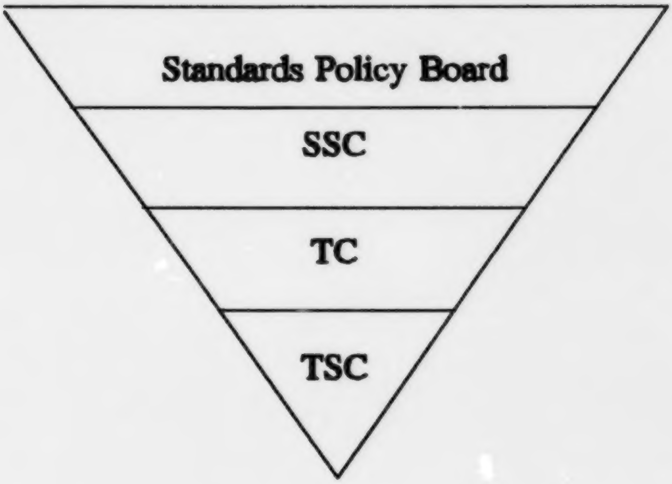

Request for a New Std
Is It Needed?
Review by:
-Task Force
- CAP
- Mgt
No
Yes
Std on hold for future consideration
Form balanced Committees/Matrices
- TC
- SSC
Development Meetings
First Draft Preparation
Drafts Expansion
G/L - F
Public Review/ Info Update
PAE
Due Process Ballot
Approved?
No
Yes
Any Negatives?
Yes
No
Dispostion of Negatives
Negatives Resolved?
Yes
No
Publication
END
SSC
Future work

FIGURE 2. FLOW DIAGRAM FOR DEVELOPMENT OFA NEW STANDARD



i) 50% of the voting members must be affirmative.

ii) 2/3 of votes cast must be affirmative.

iii) All negatives must be addressed at TC and SSC levels.

Figure 3 Balloting at Canadian Standards Association (CSA)

Phase 7 involves the publication and printing of the standards.

Balanced Matrices of Membership

The standards at CSA are developed by the committees that consist of balanced representation from users, producers, government/regulatory authorities and general interest group, with particular attention that no single group overrides the others. This ensures that the standards that are developed at CSA are well thought-out, well-written, technically sound, and neutral standards that are well respected and acceptable across the country and overseas.

Conclusion

Composting is being accepted as a viable solution to the solid waste management particularly for biodegradable kitchen and yard wastes, municipal sewage sludge, fish wastes, sheep and dairy manures, poultry carcasses etc. However, the success of the composting program at the municipal level will primarily depend on its perception and acceptance of the householders and the public in general, their confidence level,and utility and usefulness of by-products of both home composting and centralized composting. Development of nationally accepted uniform standards and guidelines will only enhance such acceptance and confidence.

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MUNICIPAL SOLID WASTE COMPOSTING: BREACHING THE BARRIERS

By: E. Shawn Worster
Vice President
CSI Resource Systems, Incorporated

This paper presents an overview of municipal solid waste (MSW) composting, including a description of available technology options, a discussion of product quality requirements, and a summary of the status of MSW-composting projects in the U.S. Drawing upon CSI Resource Systems, Incorporated's experience in representing public project sponsors and in ensuring that the requirements of the financial community are fulfilled concerning such projects, this paper also sets forth the key "ingredients" which, at a minimum, must be in place to facilitate successful project implementation.

MUNICIPAL SOLID WASTE COMPOSTING: BACKGROUND AND OVERVIEW

BACKGROUND OF U.S. SOLID WASTE MANAGEMENT PRACTICES

Approximately 185 million tons of MSW were generated from residential, commercial, industrial, and institutional sources in the U.S. during 1990. At present, about two-thirds of this MSW is disposed of in landfills. The disposition of the remaining third is split roughly evenly between recycling and waste-to-energy, with a very small percentage of the total MSW going to MSW-composting facilities.

The U.S. Environmental Protection Agency (USEPA) has established a hierarchy of preferred solid waste management techniques which guides federal, and many state, waste management policies. This hierarchy is as follows:

1. Reduction of MSW generated;

2. Recycling (including composting) of certain components of the MSW which would otherwise require disposal;

3. Recovery of energy from MSW and volume reduction through combustion in waste-to-energy facilities; and

4. Disposal in permitted landfills of that MSW which cannot be recovered for recycling or incinerated.

The goal of this national policy is to reduce the current dependence on landfilling for solid waste management, thus preserving dwindling landfill capacity, in favor of "integrated" waste management systems that better preserve air and groundwater quality by employing a mix of the first three methods listed in the hierarchy. Waste reduction through material substitution and packaging redesign, as well as the recycling of metals, glass, and paper, have grown significantly over the past several years as effective waste management techniques. Considered a subset of recycling and a viable method for reducing the volume of solid waste, MSW composting has also emerged as a growing, albeit relatively recent, waste management technique in the U.S.

The forces driving the growth of MSW composting include the previously stated national and state policies that place composting near the top of the waste management hierarchy, and the siting difficulties and increasing costs of developing new waste-to-energy capacity. MSW composting is one of the few ways to divert a significant portion of the non-recyclable category of MSW from landfills. MSW composting is only now receiving specific regulatory attention, which will have the positive effect of creating conformity within the industry.

OVERVIEW OF COMPOSTING TECHNOLOGY

The composting of MSW involves the biological degradation of the organic, or compostible, fraction of such waste. The benefits of composting include: (1) the volume reduction, as a result of the biological degradation, of waste otherwise requiring disposal; and (2) the production of compost, a humus-like material, as a usable end-product. Various levels of compost quality can be achieved, depending on the type of technology employed, the proper implementation of the various technologies, and the characteristics of the incoming MSW.

Within the realm of solid waste management, composting is currently used to reduce the volume of yard waste and MSW. Sewage sludge is sometimes used in combination with these solid wastes. Composting is also used in sewage-sludge-only applications. Yard-waste composting necessitates source-separation of the material and is typically conducted on a small scale, utilizing a low level of technology at a local landfill. The process is a simple one and involves placing yard waste in large piles and turning the piles every few months. Generally, this yard-waste composting technique requires 12 to 18 months for production of the compost end-product. There is a growing trend toward regionalizing yard-waste composting programs, thereby enlarging the scale of the operation and encouraging mechanization. Successful yard-waste composting programs rely on source separation (i.e., separation of the material from other waste by the generator) and may require capital-intensive modifications to the existing waste-collection infrastructure.

Large-scale MSW-composting projects are also being developed, and several are currently in operation. Because the development of MSW composting in the U.S. is relatively recent, there is limited domestic experience with such processes. Most of the projects draw on either U.S. experience with sewage-sludge composting or European experience with solid-waste composting. MSW composting, unlike yard-waste composting, does not require the public behavioral changes inherent in implementing source-separation programs. Neither does it require modifications to the existing collection-system infrastructure. MSW composting does require a higher level of technology, operational control, and monitoring than does yard-waste composting due to the heterogeneous nature of the incoming mixed MSW.

The marketability of compost products is highly dependent on the production of compost that is consistently of relatively high quality and on the availability of end-use markets (usually composed of local agricultural, horticultural, landscaping, and public works applications) and by emerging environmental regulations governing trace contaminants in compost. Maintaining the "cleanliness" of the MSW-derived compost product is critical to supporting its viability as a soil-enrichment material. In addition, the end-use of such compost may be subject to regulatory limitations, depending upon the intended application.

To produce a high-quality compost, it is necessary to separate to the greatest extent practicable the compostible fraction of the waste stream (i.e., green/yard waste, food waste, paper, corrugated cardboard, wood), which represents the majority of a municipal solid waste stream, from the non-compostible fraction (i.e., plastics, glass, metals, textiles, and rubber materials). A high degree of such separation ensures a lower potential for compost contamination and, therefore, a higher-quality end-product. Nevertheless, even within the overall compostible fraction, contamination can occur. However, the composting process can be controlled so as to minimize such contamination.

TECHNOLOGY DESCRIPTION

In order for MSW-derived compost to be utilized for the broadest range of applications, it must meet certain quality standards. A high-quality compost exhibits a high degree of MSW biological degradation, an acceptably low pathogen level, a relatively homogeneous particle-size range, a well balanced carbon-to-nitrogen ratio, and a low degree of contamination. Several states are developing or have adopted applicable compost regulations that impose limits on compost contaminant concentrations and particle size. These regulations also require that the compost be produced by a process employing a minimum detention time (e.g., 50 days) for active composting and curing.

To produce a high-quality compost, the technology used must control several important process variables that govern the level of composting achieved. The process variables are associated with the front-end processing of the MSW, the composting process, and the back-end compost refinement. The critical front-end processing variables include separation of non-compostible material from incoming MSW and size reduction of the incoming compostible waste. These functions are accomplished primarily at the front end of the overall composting system and are important because they prepare the waste for the subsequent composting process. These waste-processing variables are also important at the back end of the composting system for refining the compost into its finished form. The critical composting process variables include temperature, aeration, moisture content, carbon-to-nitrogen ratio, and degree of mixing. Controlling these variables so as to facilitate their optimization is crucial to producing a high-quality compost within a relatively short period of time.

There are several composting technologies offered in the marketplace, including static pile composting, aerated static pile composting, aerated turned-windrow composting, and in-vessel composting. A summary of each of these technologies is presented below.

Static Pile Composting

After solid waste is mechanically processed, it is placed into static piles until the composting process is complete. The only parameter regulated during the composting process is the moisture content of the piles, controlled through the addition of water. This is the most rudimentary composting technique and, because the piles are not turned or forced-aerated, the quality of the compost end-product is poor, and the compost production rate is extremely slow.

Aerated Static Pile Composting

After being mechanically processed, the solid waste is placed into aerated static piles that are both watered and forced-aerated (i.e., oxygen is introduced into the piles). However, moisture content and temperature are not well regulated because the piles are not turned and, hence, there is no mixing. Consequently, the compost process takes place unevenly throughout the pile, resulting in a product that is a mix of poor- to good-quality compost.

Aerated Turned-Windrow Composting

After the solid waste is mechanically processed, it is placed in long rows of piles called windrows. All the important processing variables listed previously are regulated, and the windrows are turned regularly for mixing, watered, and forced-aerated. If the process is monitored and controlled properly, the result is a high-quality compost produced at a greatly accelerated rate.

In-Vessel Composting

After the solid waste is mechanically processed, it is placed in an enclosed vessel wherein the compost is regularly mixed, watered, and forced-aerated. All the important processing variables listed previously are regulated. If the process is monitored and controlled properly, it produces a high-quality compost at a greatly accelerated rate.

PRODUCT QUALITY

Most of the physical characteristics of the final compost product (e.g., particle size) can be controlled so as to meet high-quality-compost requirements. The degree of such control over the compost's physical characteristics, however, can be affected by the system's mechanical equipment specifications and operating characteristics. The chemical characteristics of the final compost product can be controlled, to a limited degree, by removing materials causing contamination through size reduction, mechanical separation, manual separation from the pre-processed waste stream, source separation through recycling programs designed to remove hazardous materials and other potential sources of contamination from the waste stream, and biological decomposition processes. Additionally, soil amendments can be added to the final compost product and known quantities of yard and vegetative waste can be added to the pre-processed waste stream so as to reduce the concentrations of any contaminants in the resulting mix. Consequently, there are sufficient control functions and techniques available to minimize product contamination.

The potentially marketable products of an MSW-composting system are aluminum and ferrous metals (removed through mechanical processing) and compost. Both aluminum and ferrous metals, as recyclable materials, have markets. However, the aluminum and ferrous metals recovered from a commingled waste stream will be competing for markets with aluminum and ferrous metals that have been source-separated as part of recycling programs.

The marketability of compost products is highly dependent on the production of consistently high-quality compost and the availability of end-use markets for such. Compost quality criteria are defined by end-use markets (usually composed of local agricultural, horticultural, landscaping, and public works applications) and by emerging environmental regulations governing trace contaminants in the compost (e.g., metals, persistent organics, pathogens). Maintaining the "cleanliness" of the MSW-derived compost product is critical to supporting its viability as a soil-enrichment material. In addition, the end-use of such compost may be subject to regulatory limitations, depending upon the intended application.

The MSW-composting industry has been promoting the use of MSW compost in soil-amendment applications. The industry perceives these applications as strong market opportunities that have the ability to absorb large quantities of MSW-derived compost product. These markets are currently being supplied by many companies providing substitute soil-amendment products in a very cost-competitive environment.

OPERATING HISTORY/EXISTING FACILITIES

MSW composting on a regional basis began in Europe during the 1940s and 1950s. The solid waste stream at that time consisted primarily of agricultural wastes, food wastes, and paper, and could easily be reduced in size and then separated by size. However, the composition of the solid waste stream has changed over the years to include fewer (and more slowly) biodegradable and more non-biodegradable components. As a result of these changes, European composting processes have come to rely heavily on mechanical equipment such as shredders, trommels, and destoners. Many such European facilities with long, successful operating histories continue to operate today.

As previously mentioned, the U.S. has very little experience with MSW composting, especially on a large-scale basis. The lack of regulatory certainty and defined markets has been an impediment to its development. A summary of the status of MSW-composting projects in operation or under construction in the U.S. is presented in Table 1. As this table depicts, eight MSW-composting facilities are currently in operation, eleven are under construction, and one has been temporarily shut down pending zoning and other permit approval requirements. In addition, numerous MSW-composting projects are in the planning and development stages.

REGULATORY ENVIRONMENT

MSW-composting facilities are relatively new to the regulatory arena. Federal regulations specifically addressing MSW-composting facilities are not expected to be developed in the near future. Some states, however, are developing comprehensive regulations to guide the design, operation, and performance of solid waste composting facilities.

With regard to project design criteria, compost quality, water quality maintenance, and odor minimization have been critical regulatory issues. Design requirements common to MSW-composting facility regulations include:

- separation and removal of potential contaminants;
- drainage control systems;
- leachate collection and treatment systems;
- site configurations designed to control leachate release to water drainages from the facility operating area;
- air quality and odor control systems; and
- residuals handling and disposal practice.

The operating criteria address the operating and recordkeeping procedures employed at the facility. These requirements include:

TABLE 1

MSW COMPOSTING FACILITIES IN THE UNITED STATES
(OPERATIONAL OR UNDER CONSTRUCTION)

FACILITY	OWNER/ OPERATOR	STATUS	SYSTEM	DESIGN CAPACITY (TPD)	COMMERCIAL OPERATION DATE
Delaware Reclamation Project (New Castle, DE)	Raytheon	Operational	In-Vessel (Fairfield)	1000 MSW 200 Sewage Sludge	1984
Dade County, FL	Agripost	Temporarily Shut Down*	Enclosed windrow	800 (design)	1989
Escambia County, FL	Escambia County	Construction	Windrow-compost for landfill daily cover only	400	3/91
Broward County, Pembroke Pines, FL (with Dania, Hallandale & Pompano Beach)	Reuter, Inc.	Construction	Enclosed aerated windrow; Buhler Inc. Technology	667	12/91
Sumter County, FL	Americycle	Operational	Windrow	120 (design)	1988
Des Moines, IA	Trash Reduction Systems	Construction	Windrow	85 pilot-scale (60 MSW + 25 sludge) 275 (design)	1991
MacKinac Island, MI	MacKinac Island	Construction	Aerated static pile	2,000/yr (with 400 wet tons/yr sludge)	1991
East Central Solid Waste Commission, MN	Kanabec, Isanti, Chisago, Millelacs & Pine Counties	Construction	Enclosed aerated static pile (Daneco, Inc.)	250	1992
Pennington County (Thief River Falls), MN	Pennington County (owner) Future-Fuel, Inc. (operator)	Operational	Lundell with windrow composting	10 (of RDF residuals)	1985
Prairieland Solid Waste Project, MN	Martin & Faribault	Construction	In Vessel (Seres & OTVD)	100	1991/1992

TABLE 1 (Continued)

FACILITY	OWNER/ OPERATOR	STATUS	SYSTEM	DESIGN CAPACITY (TPD)	COMMERCIAL OPERATION DATE
St Cloud, MN	Recomp, Inc.	Operational	Digester with enclosed agitated-bin curing	60	1988
Swift County, MN	Swift County	Operational	Aerated windrow	25	1990
Wright County, MN	Wright County	Construction	Enclosed aerated windrow (Buhler Inc.)	165 (mechanical processing component in 8-hr period) 205 (biological processing)	Spring/Summer 1992
Portland, OR	Reidel Waste Disposal Systems	Construction	Drum with aerated static pile (Dano)	600	1991
Big Sandy, TX	Eweson/ Bedminster Bioconversion	Operational (Research Facility)	Digester with Windrow	35 with 15 sludge (seasonal)	1972
Hidalgo County, TX	Hidalgo County	Operational	Windrow	300 (design)	1/91
Bellingham, WA	Recomp, Inc.	Construction	Digester with enclosed agitated-bin curing	100	4/91
Adams County, WI	Adams County	Construction	Aerated static pile	20	5/91
Columbia County, WI	Columbia County	Construction	Drum with windrow curing	80 with sludge	7/91
Portage, WI	City of Portage	Operational	Drum with windrows	16	1986

* The Agripost Facility was temporarily shut down on December, 1990, pending zoning and other permit approval requirements.

SOURCE: Biocycle November 1990 pages 46-50
CSI update February 1991

- periodic waste characterization;
- adherence to air quality and odor emission limits;
- waste delivery, storage, and removal procedures;
- facility access control;
- residuals management;
- leachate and run-off management;
- compost operating conditions logging; and
- periodic finished product analysis.

The levels of organic, metal, and pathogenic contaminants contained in the compost determine the regulatory limits on the distribution of the compost. Compost product is placed into various product classes according to the concentrations of specified compounds found in the material. These classes determine the type of applications in which the compost can be used.

As states promulgate definitive regulations governing the design, operation, and product requirements, the following impacts on the MSW-composting industry are expected to occur:

- Regulatory standards will help to set minimum threshold levels on technologies.
- A greater level of information and detail will be required to obtain permitting of MSW-composting facilities. These regulations and the regulatory process will be a focal point for increased public participation in the permitting of these facilities.
- The costs of constructing and operating a facility will reflect the new regulations.
- Better market definition for compost products is expected to unfold. Acceptable product applications will be established, providing compost products meet certain criteria.

MSW-COMPOSTING PROJECT IMPLEMENTATION: KEY INGREDIENTS

The groundwork for facilitating successful project implementation must begin at the very outset of the project planning cycle. It begins with the proper examination and inventory of the current solid waste generation, collection, treatment, and disposal practices in the community (ies) to be served; knowledge of the relevant regulatory and legislative framework; an assessment of the long-term availability of treatment, product market, and disposal options, both local and regional; and the development of a sound, integrated solid waste management plan addressing the short-, intermediate-, and long-term treatment and disposal needs of the potential project sponsor.

In general, the project will be considered a well conceived program that provides a long-term, environmentally and economically sound method of MSW disposal as well as appropriate incentives for the profitable operation of the facility, if certain key project "ingredients" are present.

These ingredients, including the criteria related to each that will have been met as a result of a thorough project development effort, are presented below.

- AN ENVIRONMENTALLY SUITABLE SITE FOR THE FACILITY
    - A site is deemed suitable because, among other factors, it has good transportation and utility access; it is compatible with the current land use and zoning of the area; and its topography and subsurface conditions are appropriate for the proposed facility.
    - There should be no environmental, site, or facility design impediments which would prevent facility conformance to all the approved major permits relating to environmental compliance and solid waste regulations. All such major permits must be approved by the responsible agencies.

      Any additional local and/or state permits or approvals that may be required for facility construction should be obtainable in a timely manner that will not affect the facility completion schedule.
- A NEARBY LANDFILL FOR RESIDUE AND REJECT MATERIALS
    - The capacity of the designated landfill, including its expansion potential, must be sufficient to fulfill the residue and reject materials disposal needs of the facility throughout the term of the bonds.
- ADEQUATE RECOVERED MATERIAL PLACEMENT OPTIONS MUST BE AVAILABLE
    - The material placement arrangements must provide reasonable assurances that all the recoverable material produced by the facility and available for placement will be placed throughout the term of the bonds. The marketing arrangements should evidence flexibility and redundancy.
- A SOUND TECHNOLOGY AND A CAPABLE VENDOR TEAM WHO WILL ASSUME RESPONSIBILITY FOR ITS PERFORMANCE
    - The facility technology must entail a sound method of MSW disposal.

- The contractor must have the ability to design, construct, and operate the proposed facility.

- The design and construction of the facility in a manner that will result in a facility able to satisfy the acceptance test must be within the demonstrated technical capabilities of the contractor. The acceptance test should be appropriate for the facility, based upon design expectations and demonstrated performance of existing facilities of similar design, and should be passable if the facility is designed and constructed in accordance with good engineering practices applicable to facilities of its type. Once the acceptance test is passed, it should be reasonable to expect that the performance of the facility will be sustained at its annual effective design capacity if the facility is operated and maintained in accordance with good engineering practices applicable to facilities of its type.

- The schedule for completion of design, construction, equipment installation, start-up and acceptance testing of the facility should be adequate for the facility's type and size, barring any unusual, uncontrollable, or unforeseen circumstances of a material nature.

- The facility construction cost estimates made by the contractor must be reasonable and achievable, and the funds made available from the bonds and the equity contribution should be sufficient to complete construction of the facility as designed.

- The contractors's projected operating costs for the facility must be reasonable. In addition, the operation of the facility within these projected costs throughout the term of the bonds must be within the technical capabilities of the contractor.

- The contractor's projections of facility performance, including processing capacity and recovered material and residue generation, must be reasonable and sustainable over the term of the bonds once the facility passes the acceptance test, assuming that the facility is operated and maintained in accordance with good engineering practices applicable to facilities of its type. In addition, the design and operating procedures for the facility must be adequate to ensure that the facility will operate in compliance with current permit requirements.

- The facility should have a useful life extending beyond the final maturity of the bonds if it is operated and maintained, with normal parts replacements, in accordance with good engineering practices applicable to facilities of its type.

- LONG-TERM FINANCING AT A REASONABLE COST

  - The contractual arrangements among the participants in the proposed project, and the creditworthiness of each participant, should provide sufficient security to investors in the project to warrant an investment-grade rating of the bonds.

    The projected receipts resulting from the operating of the facility under normal operating conditions must be sufficient to: (i) make debt service payments on the bonds; (ii) maintain reserve funds at the required levels; (iii) operate and maintain the facility; (iv) make all other payments required of the contractor under the project agreements; and (v) provide a return to the contractor.

- LONG-TERM CONTRACTS FOR THE SUPPLY OF WASTE

  - Sufficient quantities of acceptable waste must be generated within a reasonable distance from the facility throughout the term of the bonds and must be committed or available to the facility so as to allow operation of the facility at its annual effective design capacity.

CONCLUSION

MSW composting can be a viable component of an integrated solid waste management program. Its success requires careful planning, procurement, and implementation, incorporating all of the initial elements discussed herein.

OXYGEN UTILIZATION AS AN INDICATOR OF MUNICIPAL SOLID WASTE COMPOST STABILITY

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Don Richard, Sc.D., North Dakota State University, Fargo, ND

Introduction

Municipal solid waste (MSW) has historically been land disposed. However, problems have recently been associated with this practice. As a result, several states have mandated the development of solid waste management systems which integrate waste reduction, recycling, composting, incineration and landfilling.

Composting is a favorable alternative for disposal due to the high percentage of organic matter typically found in MSW. Composting, by definition, is the controlled biological decomposition of organic wastes by microorganisms resulting in the production of a stable, humus-like substance called compost. The compost produced must be sufficiently stable so that it will not undergo further significant decomposition resulting in adverse effects when used in the environment. Compost stability is, therefore, a function of the degree of decomposition. Criteria for assessing stability have not been universally accepted, yet, there is a recognized need for the development of compost stability standards.

The research reported herein evaluated oxygen utilization parameters as indicators of MSW compost stability. Parameters evaluated were the oxygen utilization rate (OUR), specific oxygen uptake rate, five-day biochemical oxygen demand and chemical oxygen demand. In addition, other possible indicators of stability were investigated including percent volatile solids, volatile solids reduction, nitrogen content, carbon:nitrogen ratio and reheating potential (RP).

OUR, which is a measure of the rate of oxygen utilization by microorganisms in the decomposition of organic matter in compost, was observed to be sensitive to the degree of stabilization and decreased with increasing compost age and stability. OUR values near zero indicated that the compost microorganisms were in a state of endogenous respiration which is characteristic of a stable compost. Therefore, OUR was found to be an excellent indicator of stability. Of the other possible indicators evaluated, RP exhibited the strongest relationship to OUR, and therefore, stability.

Municipal Solid Waste Generation

On the average, each person in the United States generates approximately 2000 pounds (one ton) of solid waste per year (1), a large percentage of which is organic in nature. The typical composition of the MSW stream is shown in Figure 1.

Municipal Solid Waste Composting

In essence, MSW composting is a form of organic recycling. More specifically, it is the controlled biological decomposition or breakdown of organic wastes by microorganisms to produce a final product suitable for use in the environment (1,5).

During the composting process, microorganisms native to soil and organic wastes decompose the organic matter in waste material to produce a stable humus-like product. Relatively high temperatures are developed during the composting process. These temperatures serve to "speed-up" the decomposition process as well as destroy most pathogens. The complete composting process generally consists of a rapid decomposition stage followed by a curing stage. The process can take anywhere from a few months to more than a year. After curing, the final product, or compost, is suitable for use as a soil conditioner.

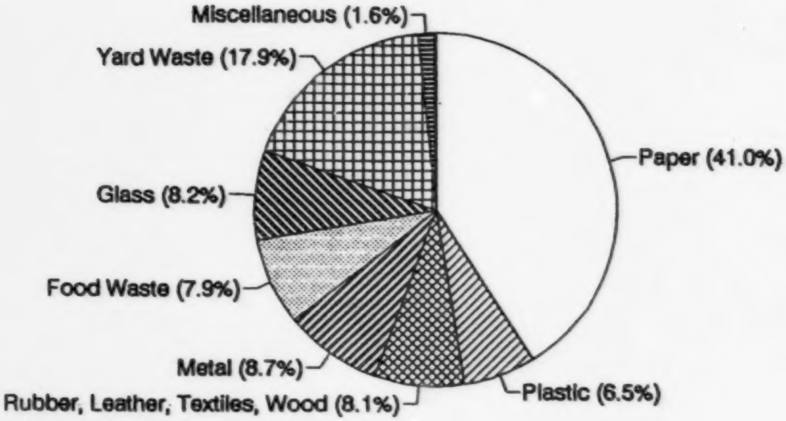

FIGURE 1
TYPICAL COMPOSITION OF MSW (2)

An Overview of Purpose for Oxygen Utilization Research

The problem of assessing compost stability is a real-life issue. Generally, there exists very little information on which to judge stability in terms of both the analyses which should be employed as well as the numerical standards which should be applied. Evidence of this uncertainty exists in various state regulations which govern compost quality (7,8,9). To date, individual state regulations are relatively weak in regard to establishing measures of stability due to the lack of experience and information available.

A number of parameters have been suggested as measures of stability. Among these are (1,10):

(1) total volatile solids reduction,
(2) microbial respiration,
(3) spontaneous heat generation or reheating potential,
(4) toxicity and/or phytotoxicity,
(5) degree of mineralization, and
(6) degree of humification.

The measurement of microbial respiration, which has received considerable attention, involves analyzing compost for the rate at which microorganisms utilize oxygen in the degradation of organic matter in the compost (10,11,12,13,14,15,16,17). The rate of oxygen utilization reflects the degree of stabilization of the product. The method for measuring microbial respiration may take various forms, however, no method has been extensively evaluated and universally recognized.

The goal of this research was to investigate and evaluate the application of respirometric or standard oxygen utilization techniques for assessing MSW compost stability.

Oxygen Utilization Rate Results

In this study, cumulative oxygen utilization was measured on a total of 22 samples of MSW compost obtained from three separate sources. The samples ranged in age from 2 days to more than 200 days. Cumulative oxygen utilization was measured over a 10 day incubation period at 20°C. The data obtained for each sample was statistically fit to a first-order expression of the following general form to determine the oxygen utilization rate (OUR):

$$y_t = y_{ultimate}(1 - e^{-(OUR)t}) \qquad (1)$$

Results of these analyses are shown in Table 1. As shown by the data in Table 1, the first-order expression provided an excellent fit for the measured oxygen utilization.

TABLE 1
OUR RESULTS

Sample Code	Sample Age	OUR (day^{-1})	R^2	F-ratio	95% Confidence Interval
R01	3	0.13	0.9970	3,347	0.13 - 0.14
R02	45	0.07	0.9991	10,634	0.07 - 0.71
R03	90	0.10	0.9989	8,828	0.10 - 0.11
R04	3	0.36	0.9925	1,332	0.34 - 0.38
R05	40	0.41	0.9789	463	0.37 - 0.45
R06	180	-0.01	0.9993	13,434	-0.01 - -0.01
R07	5	0.21	0.9983	5,958	0.19 - 0.21
R08	40	0.38	0.9822	551	0.35 - 0.41
R09	180	-0.03	0.9939	1,626	-0.03 - -0.04
R10	2	0.21	0.9977	4,424	0.20 - 0.22
R11	63	0.11	0.9995	19,756	0.11 - 0.11
R12	205	-0.06	0.9998	53,930	-0.06 - -0.06
R13	75	0.08	0.9984	6,130	0.08 - 0.08
R14	102	0.05	0.9956	2,277	0.04 - 0.05
R15	140	0.01	0.9917	1,190	0.01 - 0.01
R16	30	0.45	0.9783	451	0.41 - 0.49
R17	60	0.26	0.9846	638	0.24 - 0.29
S01	18	0.28	0.9579	227	0.23 - 0.32
S02	90	0.10	0.9979	4,653	0.10 - 0.10
F01	>200	0.00	0.9941	1,686	0.00 - 0.00
F02	135	0.06	0.9991	10,695	0.05 - 0.05
F03	>200	0.04	0.9993	14,064	0.04 - 0.04

Cumulative oxygen utilization results for three selected compost samples are shown in Figure 2. OUR, as a function of compost age, is shown in Figure 3 for all samples. In Figure 2 and Figure 3, OUR decreases as compost age and stability increases. OUR, as measured over a 10 day incubation period, approaches zero as greater stability is achieved. Young unstable composts, however, exhibit a variety of OUR values. This is represented by the scatter in the data points for low compost ages and is probably due to the heterogeneous nature of MSW. As the compost becomes more stable, it also becomes more homogeneous in nature, and therefore, OUR values tend to converge.

When cumulative oxygen utilization was fit to the first-order expression, negative OUR values were obtained for three compost samples. Initially, this would seem to be due to the limits on the accuracy of the analysis. However, a review of the statistical data for these OUR values would indicate that the negative OUR is valid. Negative OUR values were only measured on compost samples which had an age of six months or greater and which were considered to be stable as evidenced by the low OUR. Two of these samples also contained measurable quantities of nitrate-nitrogen, indicating that nitrification had begun to take place which also implies stability. Nitrification results in a second stage of oxygen utilization which is characterized by an "inversion" in the first-order expression for cumulative oxygen utilization and, would therefore, result in a negative OUR. Further investigation would be required to verify the effects of nitrification on OUR for MSW compost.

The data collected indicate that there is a relatively strong relationship between OUR and compost stability as evidenced by the definite trend toward decreasing OUR values with increasing compost age and stability. This would suggest that the OUR may be used not only as an indicator of ultimate stability, but also as an indicator of the degree of compost stability. This may be very important in regard to the intended end-use of a particular compost as ultimate stability may not be required for certain end-uses. Reduced OUR values, even though greater than zero, may be sufficient to indicate a satisfactory degree of stability under certain conditions for compost use.

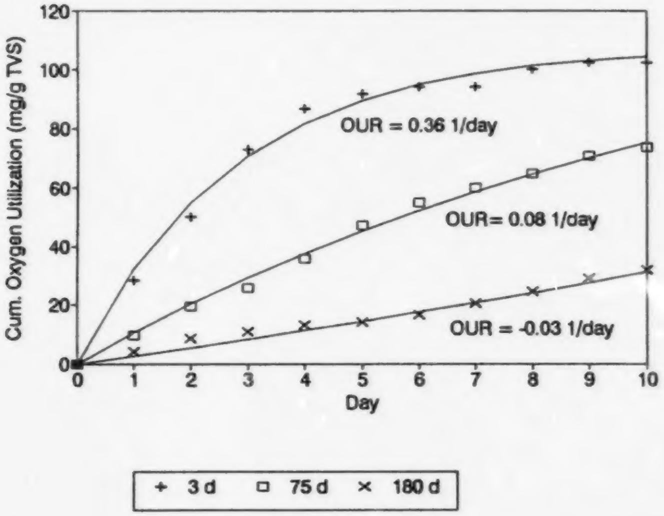

FIGURE 2
CUMULATIVE OXYGEN UTILIZATION FOR SELECTED COMPOST AGES

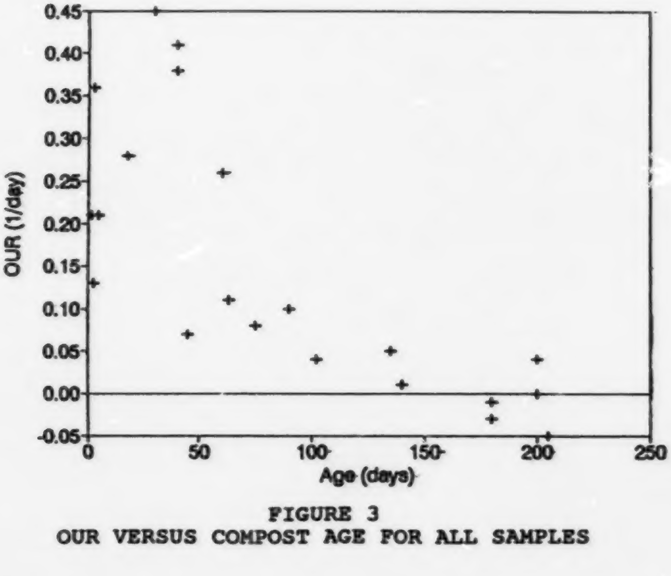

FIGURE 3
OUR VERSUS COMPOST AGE FOR ALL SAMPLES

Reheating Potential Results

Results obtained for other parameters were statistically compared to OUR to determine which parameters were most significantly related to OUR, and therefore, stability. Of the other compost parameters evaluated, RP exhibited the strongest relationship to OUR, compost age and stability. RP is a temperature-related measure of the biological activity of compost microorganisms and reflects the heat generated by microorganisms during the decomposition of the organic matter in waste material. RP analyses were conducted in the laboratory on samples of compost adjusted to a moisture content of 50%, placed in open dewar flasks, and incubated at 20°C for 10 days.

As shown in Figure 4, RP decreases with increasing compost age and stability. A RP near 20°C (0°C relative to the 20°C incubation temperature) is characteristic of stable compost. Although a standard procedure has not been widely accepted, the RP technique is relatively simple to apply and does not require sophisticated equipment. However, the analysis is very sensitive to test conditions. Performing the analysis under other than optimal conditions can result in erroneously inferring stability. The most significant test condition is moisture content. From data obtained in this study, the optimum moisture content for analysis appears to be near 45%. However, in practice, samples should be analyzed at several moisture contents selecting the highest temperature achieved from all moisture contents as the RP.

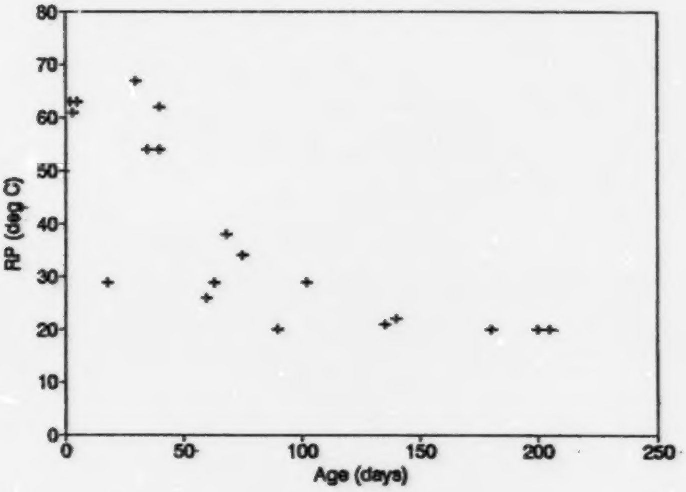

FIGURE 4
RP VERSUS COMPOST AGE FOR ALL SAMPLES

Practical Application for Monitoring Compost Stability

The results of this study support the premise that OUR should be an excellent indicator of stability. OUR provides an "inside picture" on the activity of the compost microorganisms during the degradation of biodegradable organic matter. When biodegradable organic matter is abundant, oxygen utilization rates are high because a large population of microorganisms is actively utilizing oxygen while degrading the organic matter. First-order reaction kinetics apply to this situation. When biodegradable organic matter is limiting, oxygen utilization rates are low because microorganisms are competing for scarce amounts of "food" and are not using oxygen at significant rates. A steady, low oxygen utilization rate near zero indicates that the compost microorganisms are in a state of endogenous respiration and is an excellent indicator of stability. Zero-order (linear) reaction kinetics best describe this situation.

Although compost age has been used as a base measure for stability for the results obtained, it is a less than desirable measure for evaluating stability on a wide range of composts produced at different facilities. Compost age may serve as a good indicator of stability for one particular feedstock undergoing one particular composting process. However, MSW typically varies significantly in composition and different facilities employ different variations of the basic composting process. These variations in composition and process can greatly affect the time required to obtain a stable compost. Therefore, one facility may produce stable compost in six months while it takes another facility more than one year. Age is not a widely representative and standard measure of stability. However, results obtained from the OUR analysis provide an absolute, standard measure of stability because they have theoretical as well as practical significance. Therefore, in developing a standard for stability, it is desirable to exclude age and include more desirable, absolute measures like OUR and RP.

Although OUR is an excellent indicator of stability, there are some disadvantages to its use. These include the following:

(1) The procedure used to evaluate OUR is not frequently performed by most laboratories.
(2) The equipment used to evaluate OUR is not widely standardized.
(3) As evaluated in this study, the analysis requires at least 10 days to complete resulting in a delay between sampling and obtaining results.
(4) The data obtained must be statistically fit to a first-order reaction equation to determine the OUR.

In view of these disadvantages, two possible alternative exist:

(1) Adopt and require the use of the OUR analysis as a primary indicator of MSW compost stability. This would require standardization of the technique and equipment.
(2) Relate the results obtained from OUR analyses to those obtained from other more frequently or more easily measured parameters. In this way, limits for other parameters could be used as indicators of OUR, and therefore, be used as indicators of stability. In this regard, the RP analysis would appear to be an excellent alternative.

Conclusions

The following conclusions are a result of this research and, although they are drawn specifically from the observations of this research, it is believed that they apply to MSW composts in general.

* Oxygen utilization rate (OUR) is a measure of the oxygen consumed by microorganisms in the decomposition of organic matter in waste material. OUR was found to be an excellent indicator of MSW compost stability. OUR decreases with increasing compost age and stability.
* An OUR near zero indicates that the compost microorganisms are in a state of endogenous respiration which is characteristic of ultimate stability. Therefore, OUR has significant practical value in defining compost stability.

- Reheating potential (RP) is a temperature-related measure of the biological activity of compost microorganisms. RP is related to the temperature increase resulting from the heat generated by microorganisms during the decomposition of the organic matter in waste material. RP decreases with increasing compost age and stability. RP was found to be closely related to OUR, compost age and stability.
- RP values near 20°C (0°C relative to a 20°C incubation temperature) are characteristic of stable compost.
- Because OUR is an excellent indicator of stability, it is recommended that it be recognized as a standard for assessing compost stability. In applying OUR as a stability measure, further research needs to be conducted to establish numerical values or ranges of values that establish limits for acceptable levels of stability for general end-use categories. This is necessary because ultimate stability is not required for all end-uses. It would therefore be necessary to evaluate OUR concurrently with bioassays. A standard procedure taking into consideration analysis procedures, incubation times and equipment should be adopted. To make the analysis practical for use, further research needs to be conducted to determine the shortest analysis time required to obtain accurate results.
- RP has been found to be a good indicator of MSW compost stability as evidenced by a strong statistical correlation to OUR. However, widely accepted standard procedures for analysis have not been recognized. RP has also been found to be very sensitive to test conditions, specifically to rate-limiting conditions like moisture content. Therefore, further research needs to be conducted to establish a standard analysis procedure which minimizes sensitivity to test conditions.

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NEW LOW COST INTEGRATED SEPTAGE TREATMENT SYSTEM

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1.0 INTRODUCTION

According to the Quebec Environment Ministry's Guide for the management of septic tank sludge a few treatment options are available; dewatering, lagoons, composting, chemical stabilization, addition-introduction to municipal sewage treatment plants and specialized mechanical septic sludge treatment plants.

When untreated, septage sludges introduced into a municipal sewage treatment plant upset the treatment by significantly increasing the organic load as well as that of suspended solids. Since septic sludge is generally collected during only a portion of the year, the treatment plant is subjected to seasonal variations and rush periods which require specialized and expensive equipment.

After studying the possible options, we have chosen a procedure including dewatering followed by the treatment of the reject water (liquid fraction) and of the solid fraction (20 % solids). The dewatered septic sludge can then be treated and reutilized.

2.0 SYSTEM DESCRIPTION

The proposed procedure regroups a number of steps; reception, dehydration, reject water treatment and solids treatment by composting.

i) Dehydration, DAB_{tm}

The DAB_{tm} system is the heart of the treatment procedure and it allows the dewatering of sludge based on a combination of decantation and filtration through membranes. For septic tank sludges the DAB_{tm} system includes screening, a storage reservoir, a floculant dosage unit, the DAB_{tm} dehydration unit, an evacuation system and/or dehydrate sludge treatment and filtrate treatment.

The DAB_{tm} unit consists of a passive filtration/decantation mechanism. The collector allows the removal of an important part of the liquids contained in the sludge (90 % in the case of septic sludge). This filtrate, whose organic and suspended solids are reduced by at least 90 % and 99 % respectively when compared to the raw sludge, is discharged and can then be treated by different methods.

ii) Reject water treatment; $Mediaflex_{tm}$ filter

The reject water can be incorporated into municipal sewage treatment system without requiring specific modifications of the latter, as long as its treatment capacity isn't reached. It is also possible to proceed with a pretreatment of the filtrate before it is introduced into the sewage treatment plant or construct an independant treatment plant which discharges into the regional surface drainage network. The integrated system proposed by Serrener Consultation inc., includes treating the reject water by a biofilter developped by the company.

The filtration system uses multiple layers. The thickness of the layers varies according to the characteristics of the liquid to be treated. Sphagnum peat moss composes one of the layers; the purification capacity of this dead partially decomposed vegetable matter has long been recognized. Sphagnum's cellular structure, its large specific surface, its porosity and its ionic exchange capacity give it four removal mechanisms; ionic exchange, metal complexation, adsorption and solids filtration. The second layer is composed of activated carbon wich allows for removal by chemical adsorption, chemical precipitation and solids filtration.

iii) Composting

The dewatered sludge is collected at the base of the DAB_{tm} and can be integrated into the sludge treatment system at the plant or can follow an independant treatment channel.

The aerated composting platforms are 8,7 m X 14,6 m and are protected by a shelter. The platform is divided into four composting alleys 3,5 m wide and 7,4 m long. Two blowers per alley are needed to aerate the pile of the dehydrated sludge/carbon substrate mixture. Air is feed to perforated tubes sitted on the concrete platform through the mixture. A layer of wood chips covers the tubes and the mixture prevent clogging of the tubes and control odors respectively of the solid fraction.

Composting is prefered over chemical stabilization for a number of reasons;

- composting allows for the production of a final product whose physical characteristics are more suitable for amending the soil. Whereas the texture of sludges treated by addition of lime remains plastic and non-porous;
- composting allows for the production of an hygienic product of minimal risk to human health; lime treatment is also very efficient for destruction of pathogens but

does not reduce the potential for an eventual refermentation of the material;

- composting produces a stable organic matter free of odours;

- composting produces a final product with a low water content which can be manipulated and stored easily;

- composting produces a neutral product which offers great flexibility for future use; lime treated sludges have a high pH which may not be an appropriate amendment for all type of soil;

- composting energy requirements ar low.

The proposed composting method is by static aerated piles with temperature feedback control, generally known as the Rutger's method.

The Rutger's method was chosen because it offers some undeniable advantages:

- its efficency; it allows for composting large amounts of materials on limited surfaces;

- its relative simplicity; the system is simple and can be automated to reduce manpower requirements;

- its control over odour production;

- its reasonable construction and operation costs.

Figure 1 presents the schematic flow diagram of the proposed treatment and septic sludge valorization procedure.

3.0 SYSTEM YIELD

The next figure presents the layout for an integrated septic sludge treatment and valorization system. The required surface is 4 200 m^2 (60 m X 70 m).

i) Sludge dehydration : DAB_{tm}

At the experimental station in Cowansville, Quebec, operation parameters and samples were taken over 17 cycles between October 25 and December 4, 1990. A sample series was taken for every 15 000 treated gallons on average, at the input and the exit of the system, for:

- raw sludge;
- liquid DAB_{tm} filtrate;
- dehydrated sludge.

Flow Diagram

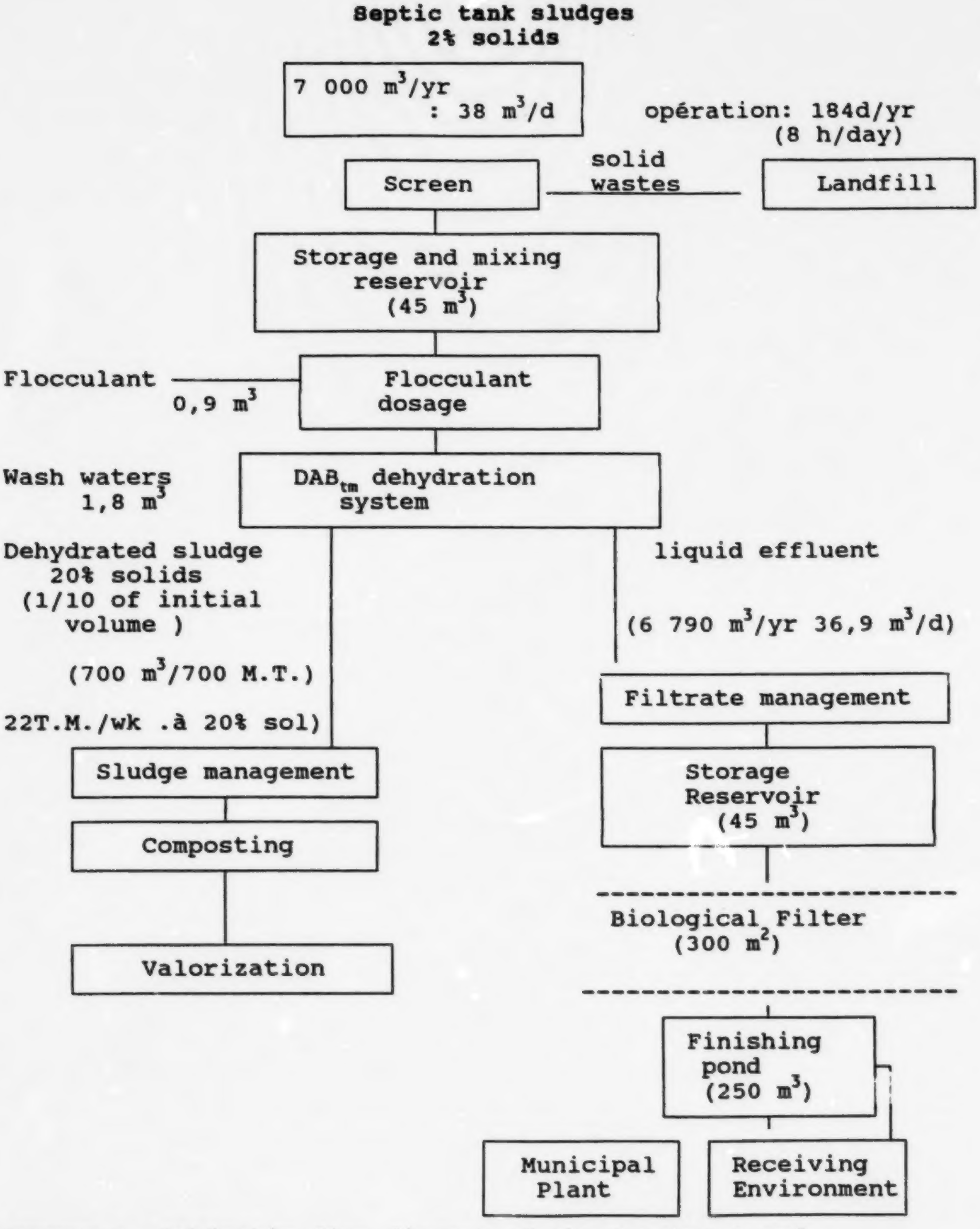
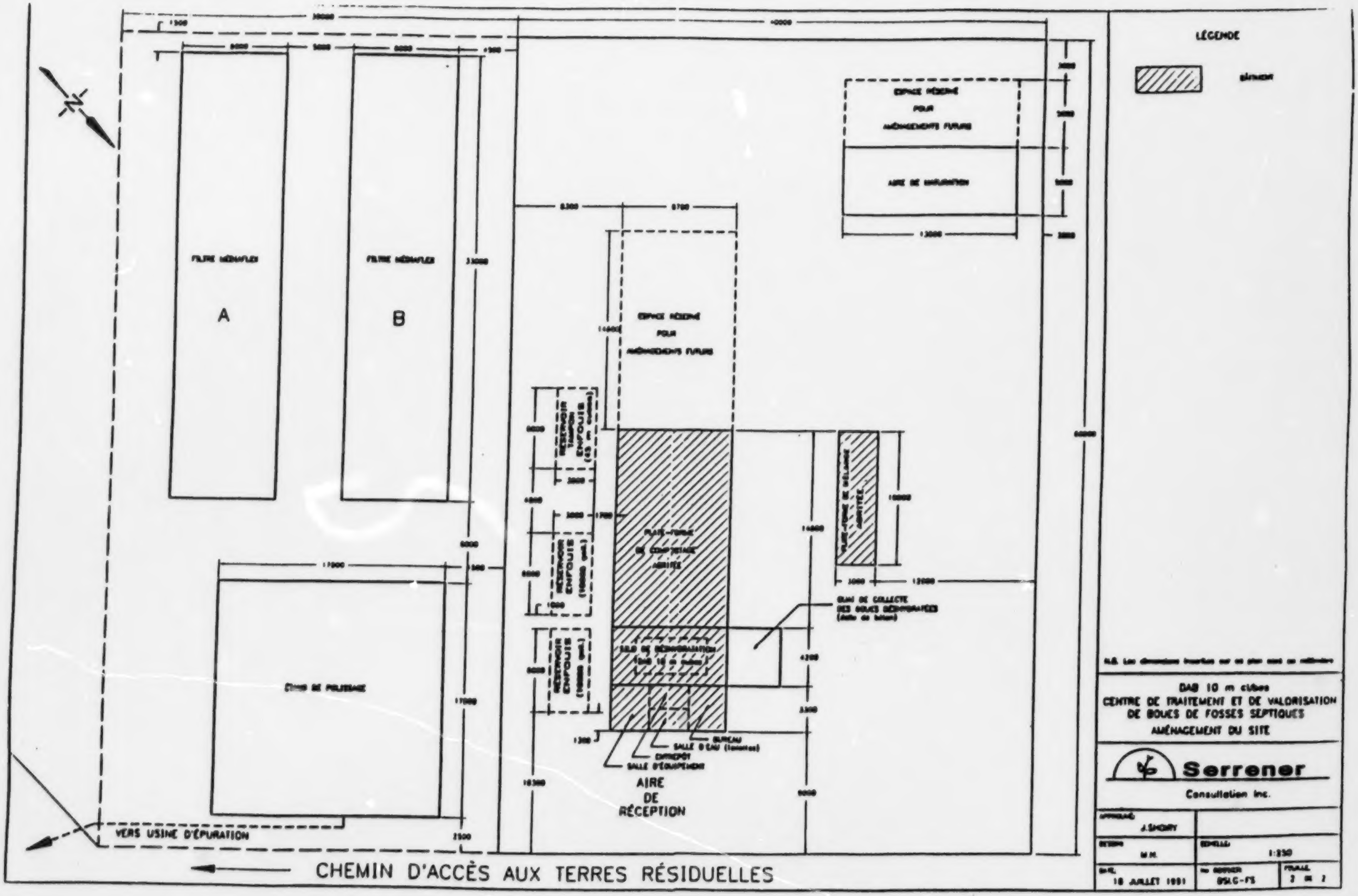

Septic tank sludges
2% solids
7 000 m³/yr
: 38 m³/d
opération: 184d/yr
(8 h/day)
Screen
solid wastes
Landfill
Storage and mixing reservoir (45 m³)
Flocculant
0,9 m³
Flocculant dosage
Wash waters
1,8 m³
DABtm dehydration system
Dehydrated sludge
20% solids
(1/10 of initial volume)
(700 m³/700 M.T.)
22T.M./wk .à 20% sol)
liquid effluent
(6 790 m³/yr 36,9 m³/d)
Filtrate management
Storage Reservoir (45 m³)
Sludge management
Composting
Valorization
Biological Filter
(300 m²)
Finishing pond
(250 m³)
Municipal Plant
Receiving Environment

FIGURE 1- Schématic flow diagram of the treatment and valorization procedures for septic tank sludges (daily capacity of 38 m^3 (8360 gal.)).


LÉGENDE
BÂTIMENT
ESPACE RÉSERVÉ POUR AMÉNAGEMENTS FUTURS
AIRE DE MATURATION
FILTRE MÉDIAFLEX
A
B
ÉTANG DE POLISSAGE
RÉSERVOIR TAMPON ENFOUIS
RÉSERVOIR ENFOUIS
PLATE-FORME DE COMPOSTAGE ABRITÉE
PLATE-FORME DE MÉLANGE ABRITÉE
SALLE DE DÉSHYDRATATION (DAB 10 m cubes)
QUAI DE COLLECTE DES BOUES DÉSHYDRATÉES (dalle de béton)
BUREAU
SALLE D'EAU (toilettes)
ENTREPÔT
SALLE D'ÉQUIPEMENT
AIRE DE RÉCEPTION
VERS USINE D'ÉPURATION
CHEMIN D'ACCÈS AUX TERRES RÉSIDUELLES
N
1300
5000
3000
4000
5000
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3000
13000
14000
12000
17000
9000
10300
4200
3300
1300
1000
1700
2500
N.B. Les dimensions inscrites sur ce plan sont en millimètres
DAB 10 m cubes
CENTRE DE TRAITEMENT ET DE VALORISATION
DE BOUES DE FOSSES SEPTIQUES
AMÉNAGEMENT DU SITE
Serrener
Consultation Inc.
J. SHORY
M.M.
1:250
10 JUILLET 1991
BSLC-FS
2 de 2

Raw sludge and filtrate, were analysed for 23 parameters whereas dehydrated sludge were analysed for 25 parameters. Choice of analytic parameters is based on various standards used in environmental regulations and guidelines.

The system's yield was evaluated through four aspects:

- treatment capacity;
- dewatering efficiency;
- reduction of pollution bods in the liquid effluent as compared to raw sludge;
- quality of final sludges.

The treatment capacity of the Cowansville plant is 6 000 imperial gallons of septic sludge (27 m^3) per cycle. Since it is possible to operate two cycles per day, the total daily capacity for this installation is 12 000 imp. gal. (54 m^3).

Considering that April 15 to november 15 (32 weeks), 6 days per week (192 days) is the most probable operational period, the annual capacity is then 2,3 million imp. gal. (10 500 m^3).

Table 1 compares the septic sludge characteristics at the Cowansville station with average septic sludges observed in Quebec and United States.

Table 2 shows the characteristics of the raw septic sludge and the liquid effluent rejected from the DAB_{tm}.

The percent removal (final column) is greater than 90 % for the most the parameters. The lower removal efficiencies were obtained for ammonia (22 %) and phenols (35 %). The greatest removal percentage were observed for oil and greases, suspended solids and coliforms, all being above 99 %. All metals, with the exception of boron, were also significantly reduced (88 % to 99 %). The biological oxygen demand was reduced by 92 %.

TABLEAU 1

Comparison of the septic sludge characteristics received at Cowansville and the average for Quebec and the united States

		Main values		Ratio		Ratio
Parameters	Units	Cowansville	Québec(1)	Cowans./ Québec	aver.(1) Etats-Unis	Cowans./ Etats Unis
pH	--	5,9	--	--	6,9	0,86
BOD_5	mg/l	6 979	--	--	6 480	1,1
CDO	"	19 537	--	--	31 900	0,61
O & G	"	7 200,0	--	--	5 600	1,29
SS	"	17 311	44 765	0,39	12 862	1,34
Phenol	"	--	--	--	--	--
Sulfates	"	54,0	--	--	--	--
NH_3	"	169	78	2,17	97	1,74
NTK	"	596	860	0,69	588	1,01
P Total	"	100,79	236	0,43	210	0,48
Boron	"	2,03	--	--		--
Mercury	ug/l	11,6	--	--	230	0,05
Arsenic	"	71,1	14 700	0,005	160	0,44
Selenium	"	16,6	520	0,03	76	0,22
Cadmium	mg/l	0,06	0,35	0,17	0,27	0,22
Chromium	"	0,72	0,87	0,83	0,92	0,78
Copper	"	7,80	13,5	0,58	8,27	0,91
Iron	"	220,04	227	0,97	191	0,51
Nickel	"	0,68	0,48	1,42	0,75	0,32
Lead	"	2,63	7	0,38	5,2	1,09
Zinc	"	8,67	35,9	0,24	27,4	1,11
Tot.Colif.	ufc/100 ml	109×10^6	--	--	10^8	
Fec. coli.	"	$11,1 \times 10^6$	--	--	10^7	

Guideline for management of septic sludges, MENVIQ, January 1988.

TABLEAU 2

Characteristics of raw septic sludge and liquid effluent rejected from the DAB_{tm}

Parameters	Units	Raw sludges entry of DAB_{tm}*	Nb. of samples	Liquid effluent of DAB_{tm}*	Nbn of samples	Percent removal
pH		5,9	17	6,8	17	--
BOD_5	mg/l	6 979	6	506	6	92,75
CDO	"	19 537	17	1 250	17	93,60
Oil and greases (O & G)	"	7 200,0	3	2,6	3	99,96
S.S.	"	17 311	17	81	17	99,53
Phénols	"	1,20	9	0,78	9	35,00
Sulfates	"	54,8	15	1,3	17	97,4
Total nitrogen (TKN)	"	596	16	156	17	73,8
Total ammonia (NH_3)	"	169	3	132	3	22,1
Total phosphorus	"	100,79	16	18,06	14	82,04
Chromium	"	0,72	17	< 0,05	17	> 93,06
Copper	"	7,80	17	0,04	17	99,49
Cadmium	"	0,06	17	< 0,02	17	> 66,66
Iron	"	220,04	17	5,19	17	97,64
Nickel	"	0,68	17	0,07	17	89,71
Lead	"	2,63	17	0,08	17	96,96
Zinc	"	8,67	17	0,12	17	98,62
Arsenic	ug/l	71,1	4	2,9	4	95,95
Selenium	"	16,6	4	1,7	3	89,89
Boron	mg/l	2,03	4	0,68	4	66,50
Mercury	ug/l	11,6	4	1,3	2	88,81
Tot. colif.	ufc/100 ml	109 000 000	17	708 000	17	99,35
Fec. coli.	"	11 550 000	17	120 000	17	98,96

* Average results

The yield removal efficiency is linked to the fact that the contaminants are in a particulate form or associated with the solid phase.

The dehydrated sludge characteristics are presented in table 3, along with standard maximum accepted values for agricultural use of sludges (Que. Env. Min. 1987). When we compare the standard deviation of the results with the average we note that the most variable parameters are boron, mercury, selenium, coliform bacteria and zinc. Organic matter, pH, percent total dry matter, nitrogen, phosphorus, cadmium and nickel were the most stable parameters.

We note that for all metals, mandatory maximum concentration limits are met for all parameters. With the exception of molybdenum, metal concentration of dehydrated sludge is less than 1/3 of the mandator limits. According to these standards, the dehydrated septic sludges are acceptable for future agricultural use.

ii) Filtrate treatment : Mediaflex$_{tm}$ filter (MFF)

The filter did not suffer any problems other than those associated with plugging and drainage. Twice during the summer the surface of the filter was scarified to break the thin crust which had formed on the first 2 or 3 cm. The rate of infiltration then increased. Generally, the flow at the filter exit was rapid (up to 1 gallon/second) and was proportional to input flow.

Effective life expectancy of the MFF is a function of incoming of contaminants bading and volumes of liquids to be treated. Under normal operating conditions, the pH filtrate is a good indicator of the efficency of the filter. When the pH decrease to values under 9.0 units the filter materials are usually sufficiently loaded to cause a reduction in the filtering capacity of the MFF.

TABLEAU 3

Dehydrated sludges composition as compared to maximum accepted values for agricultural use

	Maximum concentration	Maximum mandatory concentration	Dehydrated Sludge by DAB(1)	Ratio: DAB / Mandatory values
Arsenic	15	30	1,7	0,06
Boron	100	200	14,55	0,07
Cadmium	10	15	4,2	0,28
Chromium	500	1 000	22	0,02
Cobalt	50	100	< 10	0,1
Copper	600	1 000	330	0,33
Manganese	800	1 500	176	0,12
Mercury	5	10	0,914	0,09
Molybdenum	20	25	23	0,92
Nickel	100	180	20	0,11
Lead	300	500	114	0,23
Selenium	14	25	1,4	0,06
Zinc	1 750	2 500	120	0,05

Expressed in mg/kg solids

Référence : La valorisation agricole des boues de stations d'épuration, MENVIQ, 1987

(1) Average results obtained from Cowansville plant

TABLEAU 4

Average chemical composition of raw sludge and estimated removal by DAB$_{tm}$ treatment and subsequent Mediaflex$_{tm}$ filtration (results are in mg/l except for bacteria UFC/100 ml)

		TREATMENT DAB		FILTRE MEDIAFLEX				
	Raw sludge(1)	% Removal	Filtrate	% Removal	Filtrate	Sanitary landfill	irrigation water	Potable water
COD	19 537	94	1 266	78	278	100		
BOD$_5$	6 979	93	506	63	187	40		
Oil + grease	7 200	99	2,6	97	0,08	15		
SS	17 311	99	81	96	3,2			
VS	n/d	n/d	n/d	98	n/d			
Tot. sol	n/d	n/d	n/d	65	n/d		500-3 500	500
Phenols	1,20	35	0,78	97	0,02	0,02		0,002
Sulfates	51,0	97	2,0	99	0,02	2		0,5
N-Total	567	74	156	62	59			
N-NH3	n/d	n/d	n/d	40	n/d			
N-NO3	n/d	n/d	n/d	20	n/d			10
P-Total	108,8	82	18,1	98	0,36			0
Bacteria								
Tot.coli.	109 000 000	99	713 000	90	71 300	2 400		
Fec.coli.	11 550 000	98	120 000	90	12 000	200		
METAUX								
Aluminium	n/d	85	n/d	99	n/d		5	
Cadmium	0,06	> 66,6	< 0,02	--	< 0,02	0,1	0,01	0,005
Chromium	0,72	> 93,0	< 0,05	--	< 0,05	0,5	0,1	0,05
Cobalt	n/d	n/d	n/d	--	n/d		0,05	
Copper	7,8	99	0,04	87	0,005	1	0,2-1,0	1
Iron	220	78	5,2	95	0,26		5	0,3
Manganese	n/d	n/d	n/d	94	n/d		0,2	0,05
Molybdenum	n/d	n/d	n/d	--	n/d		0,01-0,05	
Nickel	0,68	90	0,07	40	0,04	1	0,2	
Lead	2,63	97	0,08	56	0,035	0,1	0,2	0,05
Zinc	8,67	98	0,12	96	0,005	1	1-5	5

(1) Characterization from Cowansville plant, Fall 1990

(2) Sanitary landfill maximum values for rejected waters, MENVIQ rule C.Q.2.R.14

When we examine the results of the filter effluent we note a gradual reduction in pH from a maximum of 12,4 to a value close to 9 by the end of the experiment. The filter materials could have been replaced after filtering about 500 000 gallons.

The efficency of the filter was evaluated by calculating the removal percentage using average results for each parameter. High removal percentages (> 80 %) were observed for the following parameters :

- chemical oxygen demand
- oil and greases
- suspended solids
- phenols
- sulfates
- total phosphorous
- boron
- some heavy metals (Al, Cu, Fe, Mn, Zn)

Variable removal rates were observed for other parameters :

- BOD_5 (60 - 65 %)
- total solids (60 - 70 %)
- total nitrogen (60 - 65 %)
- ammonia (4 - 40 %)
- nitrates (25 %)
- cadmium (25 %)
- nickel (40 %)
- lead (48 - 64 %)
- sodium (15 - 16 %)
- mercury (60 - 80 %)
- arsenic (23 - 40 %)

Bacterial content was also analysed for some sludge samples at different stages in the treatment procedure. Removal of coliforms and fecal Streptococci by filtration was signifiant and the Mediaflex$_{tm}$ filter allowed for an even greater reduction. A complete sterilization of the effluent can be achieved if desired.

iii) Composting

The following equipments are required for composting dehydrated sludges.

- mixing area (exterior) floor about 30 m^2, made of bituminous with drainage installations for run-off waters.

- composting shelter, includes concrete composting slabs, blowers, aeration tubes and control panels.

  One side of the shelter remains open and only removable canvas liners may obstruct access.

  - total shelter surface: 127 m^2;
  - aerated composting surface: 25,9 m^2 X 4 alleys (103,6 m^2 total)
  - compost moving area, work area, drainage and blowers area: 23,4 m^2;
  - composting time: 14 days.

- Compost maturation area: 5 m X 13 m, totalizing 65 m^2

  - stay time: 28 days;
  - finished bituminous concrete surface;
  - canvas covers to protect compost from precipitations.

The aerated composting platform is built annexed to the building housing the dehydration unit.

The dewatered sludges coming out of the DAB are accumulated in a tub below the DAB silo and moved by a frontened loader to the mixing platform about 30 m^2.

Given the relatively small volumes of sludge, a commercial mixer would not be profitable.

A rapid mixing of the sludge and of the structuring agent and the immediate formation of piles is necessary for the prevention of odours.

The aerated platform is made of concrete and is closed on three sides. A slope allows for the flow of leachate water towards a collection drain. The platform is 103,6 m^2 and is divided into four alleys. Each alley can receive 46 m^3 of material. Some compost is recirculated into the system since the dehydrated sludges are mixed with part of the finished compost so as to establish a c/n ratio and a humidity content favorable for the process. The mixture is placed on a 20 cm layer of woodchips and sawdust within which the aeration tubes are covered and protected from clogging.

At the beginning of the composting operations, the blowers are periodically used to initiate the composting process and accelerate the rise in temperature resulting from biological activity. When maximum threshold temperature is reached (around 60°C), the temperature feedback system is made operational. This system activates the blowers for a predetermined period as soon as the threshold temperature is reached. This control allows the maximization of the rate or oxygenation and subsequent decomposition of organic matter.

The aerated platform procedure tends to dehydrate the material adequately so a subsequent dehydration phase after aging is usually not necessary. The system is conceived in a way that should eliminate the production of leachate. However the impermeable platform, the slope (0,5 %) and collection drain would permit the potential leachate to be transfered to the water treatment plant.

4.0 CONCLUSION

As the results show, the proposed concept can offer an integrated solution to an existing problem. Many advantages can be underlined including the reduced surface requirements, the social acceptance of such a project, the adequate control of sludge arrivals and environmental nuisances, the valorization of the sludge and the reasonnable costs associated with installations and operations of the system.

The total investment costs will vary from 250 000 $ to 400 000 $ according to the specific scenarios. It is possible to offer the complete treatment for a cost between 18 $ and 30 $ per cubic meter. The operation costs are variables and are depends on the received volume. The system can treat up to about 140 m^3 of sewage sludge daily.

COMPOSTING AND WASTE REDUCTION

Notes for an address

By

Dr. Peter Meyboom
Executive Director of the
Composting Council of Canada

To

A Waste Management Seminar for
Medical Devices Manufacturers and Distributors.

Toronto, October 17, 1991

COMPOSTING AND WASTE REDUCTION

Introduction

The purpose of this presentation is to give a brief introduction as to how composting will become an increasingly important technology in decreasing Canada's Waste Stream.

The structure of the presentation is as follows:

- First I will explain what composting is, how it is being used, particularly in Europe, as a cost-effective means of reducing the waste stream and a means of recovering - economically and efficiently- as much as possible of the carbon from all organic wastes that would otherwise be lost in landfills or destroyed in incinerators.
- Next I will examine the make-up of typical municipal waste streams and assess what percentage of municipal waste could be composted and the degree of interest that exists at the moment among Canadian governments and municipalities in composting as a waste management solution.
- The third part of my speech deals with some forthcoming waste-reduction regulations in Ontario and what obligations and opportunities they create both for the members of this Association and for your clients.
- Finally, I will review the institutional arrangements that would seem to be appropriate for composting to make a significant contribution to Canada's goal of reducing solid waste by 50% by the year 2000, and to the Ontario Waste reduction program in particular.

COMPOSTING TECHNOLOGY

Composting is an accelerated oxygen-dependent natural degradation process by which organic wastes decompose under controlled conditions. The controlled conditions are mainly moisture and oxygen which are needed by the micro-organisms that metabolize organic matter. Heat is a by-product of the process and internal temperatures of a typical composting pile range from 48° to 71° C, with an optimum range of 55-60° C. The U.S. Environmental Protection Agency considers these temperatures sufficient to destroy pathogens after a minimum of 5 days. The draft Ontario composting guidelines call for a temperature range between 55 and 60° C for at least 15 consecutive days to inactivate pathogens.

The decomposing waste loses between 40 and 75 percent of its original volume. The final product is a stable, hygienic, humus-rich substance. It emits no bad odours and its nutritional content is readily available for plant uptake when it is applied to the soil. Consequently, compost is typically used as a soil conditioner, as landscape mulch, to re-surface eroded landsites, or as landfill cover.

Composting can be done with as little or as much technical intervention one desires. It can be done in small backyard bins, in open windrows which are turned periodically by man or machine, in static piles which are mechanically aerated, or in large or small rotating vessels with continuous feeding systems. The latter are generally placed in a building. A recent publication by the Environmental Sciences Research Centre at the University of Moncton for the New

Brunswick Department of Environment identified some 30 existing commercial composting systems now in use across the world.

The speed at which composting takes place depends on the nutrients available to the micro organisms as measured by the carbon/nitrogen (C/N) ratio of the waste material. The higher the carbon content, the slower the decomposition. The most efficient ratio is around 30:1. Typically C/N ratios for municipal wastes range from 40:1 to 100:1. Yard wastes range from 20 to 80:1, and manure 15 to 20:1. As the composting proceeds and the oxidized carbon is lost to the atmosphere, the ratio narrows. Finished compost has ratios of 10 to 15:1. To narrow C/N ratios, nitrogen rich wastes such as sewage sludge or manure may be added to other wastes such as wood chips or saw dust which -by themselves- have C/N ratios of the order of 500:1. In the words of Dr. Mathur, formerly of the federal Department of Agriculture, "Composting starts with matchmaking" in that most materials require to be mixed with others to obtain proper conditions of physical state, pH, C/N ratio, and moisture content.

Apart from a favourable C/N ratio the composting organisms need water to grow. A moisture content of 50-60% of total weight is considered to be ideal. Higher percentages tend to create anaerobic conditions producing bad odours and acids.

As composting is an aerobic process, the third ingredient is oxygen. Oxygen levels between 5 and 15 percent are recommended. Lower levels create anaerobic conditions whereas higher levels tend to be associated with excessive ventilation and a concomitant loss of temperature.

As for the technical aspects of large-scale composting, the most important pre-processing step has to do with the manner in which the waste is collected. Compostables are either segregated at source or at a central processing facility. Some facilities shred or grind compostable material before processing to decrease particle size, increase surface area and ensure homogeneity. After processing the finished product is generally screened to remove debris and to improve appearance.

What are the **costs and benefits** of composting? First the costs. They relate to collecting, separating and processing the waste, compost storage (and marketing), technical assistance, administration and public education. With respect to public education, its is interesting to note the results of a recent survey in New Brunswick which showed that 70 percent of the respondents either agreed or strongly agreed that compost made from municipal waste (garbage) is an acceptable product.

Benefits are derived from revenues received from selling the finished product, avoiding costs by using compost as a substitute for soil conditioners, top soil or fertilizer, and avoiding tipping fees associated with land filling or incinerating the original wastes. With ever increasing tipping fees, composting is clearly becoming a cost-beneficial form of waste treatment.

MUNICIPAL WASTE

To appreciate the potential of composting as a form of waste treatment, one only has to look at the make-up of typical waste streams. Most studies of residential waste show paper to be the predominant component at about 40 percent. Food wastes are next at about 20 percent, about 15 percent of the waste stream is yard waste and the rest are plastics, metals, glass, wood, ceramics and chemicals. A well-publicized experiment in Guelph, Ontario, showed slightly higher percentages for the combination of food (22%) and yard waste (22%) as compared to paper (26%), but the three components again make up about three-quarters of the waste stream. Joseph Kennedy, President of WCI Waste Conversion Inc. reports 40 percent paper, 23 percent yard waste and 9 percent food waste for the region of Hamilton-Wentworth, again adding up to just over 70 percent. Assuming that about 30 percent of that original waste stream is recycled, he concluded that about **40 percent remains as compostable waste**.

In Europe, municipal composting has been practised for years as the lack of landfill sites caused a "waste crisis" much earlier than in North America. According to a recent inventory done by the Environmental Sciences Research Centre at the University of Moncton, there are at least 160 facilities operating in Europe. Of these 90 are in France and 30 in Italy.

BioCycle's 1990 survey of solid waste composting projects reported that there could be about two dozen projects in operation in the United States by early 1992.

With the exception of a facility serving a group of municipalities around Chertsey, Quebec, there are no full-scale municipal composting systems in Canada as yet. However, many projects are under study or at the preliminary engineering stage. In Ontario alone, there are studies and projects in Windsor, Guelph, Hamilton, Peel Region, Greater Toronto, Scarborough and Kingston. The Ontario Ministry of the Environment intends to make composting of leaf and yard waste mandatory in those municipalities where separate collection of such waste was in place as of January, 1991.

The Province of New Brunswick intends to replace over 200 dumpsites in the province with 12 state-of-the-art regional waste management systems many of which will include composting.

Major cities in Quebec and British Columbia are interested in composting as a cost-effective method of dealing with municipal waste.

However, residential waste is less than half the story. The Industrial-Commercial Institutional Sector (ICI) of society is responsible for approximately 60 percent of a municipal waste stream; at least in Ontario. Most ICI waste is collected by private waste management companies and disposed of in municipal landfills. Although the Ontario Ministry of the

Environment acknowledges that some ICI waste generators have been recycling substantial quantities of materials, Ontario has no ICI-equivalent of the residential blue box program. Regulations are now being proposed to change that.

For the purposes of applying the proposed regulations, the ICI Sector is classified by MOE in two categories: **Waste Generators and Major Packaging users.**

NEW REGULATIONS

With respect to waste generators, the draft regulations identify the construction industry, demolition businesses, educational institutions, food services with more than $5 million annual sales, health care facilities with more than 100 beds, hotels and motels of 75 beds or more, manufacturing establishments, apartment buildings, office buildings and retail shopping complexes over 10.000^{m2}. As of July 31, 1992, establishments in these priority categories will be required to carry out **waste audits** and to develop **waste-reduction work plans**. Such plans include requirements for separating identified materials (old cardboard, wood, drywall, fine paper, newsprint, aluminum, ferrous, glass) which are essentially those materials now collected in the residential blue box program.

ICI Waste Generators will be required to collect, handle and store source-separated materials, train personnel and direct source-separated materials, to "beneficial uses." It is of importance to note that an "ICI Waste Generator" (in the language of the draft Ontario regulations) may implement a waste reduction program independently or in cooperation with other waste generators.

Before examining the implications of these regulations for the members of your association or for the **clients** of the members of your association, let us briefly examine the second family of proposed regulations; those applying to the major packaging users.

As defined in the Initiatives Paper No. 1 which was released by the Hon. Ruth Grier on October 9:

"Persons owning or responsible for the following types of ICI facilities will be responsible for **packaging audits** and **packaging waste reduction work plans**

- Food manufacturing establishments of 100 employees or more
- Beverage manufacturing establishments of 100 employees or more
- Paper or allied products manufacturing of 100 or more employees
- Chemical or chemical products manufacturing establishments with 100 employees or more (including SIC category 3741" Pharmaceutical and medicine industry)

Each packaging audit will identify and measure all the packaging materials and packaging purchased by the prescribed user. The audit will be the basis for a **packaging reduction plan** to maximize packaging waste diversion from disposal.

Now, what has all of this to do with your business and with the business of your clients?

First you. Of the 124 members of this association listed in your 1990-91 annual report, 100 reside in Ontario. Although not among the priority waste generators who are expected to comply by July 1992 the draft regulations says that **all** other waste generators shall complete a waste audit and work plan by December 31, 1993. Some of you, in the dual capacity of waste generator and major packaging user may be required to do both: The Waste Audit and the Packaging Audit.

The draft regulations are open for consultation until December 6, 1991 and I am sure the MEDEC Waste Management Task Force will want to study these proposals and comment on them as they apply to member companies.

However, a more important linkage may be the one to your clients. Assuming that your typical client is a hospital, the regulations clearly include hospitals among the waste generators and, we are fortunate to have been told about the research done by Ortech International at the Ottawa General Hospital.

If the Ottawa study is at all characteristic, we observe that at 47% paper makes up the bulk of the waste stream. Of that Ortech judged about 14% to be "probably non-recyclable", which included "wet paper and gauze, medical sterile packaging, hairnets, boots and miscellaneous paper". Food is the second largest component at 16.6 percent. Plastics are third

(13.8%), with wood, glass, and metal making up about 8 percent. Actual biomedical waste only accounted for 4.9 percent.

Leaving aside the biomedical waste which requires special provisions, the Ortech study shows that the general waste stream of a hospital is not **that** different from residential waste. Based on its findings, Ortech judged at least one-third of the entire waste stream to be compostable.

NEW PARTNERSHIPS

Of course, hospitals will have to do their own waste audits and develop their own waste reduction action plans, but to the extent that much hospital waste is probably waste packaging material, I would suggest that it might be mutually beneficial for you not to wait for provincial regulations affecting your industry, but to develop your packaging reduction plans in concert with hospital waste reduction programs.

Secondly, I suggest that you examine to what extent your packaging can be made from compostable materials because it is clear that composting offers hospitals an opportunity to divert at least one-third of their current waste stream.

Whether hospitals will turn to composting as a means of reducing their waste and **how** they would do that is still an open question. A number of factors will determine the outcome of that question.

The draft Ontario guidelines are only a first step in that they emphasize composting facilities for leaves and yard waste, thereby ignoring that for many categories of "ICI Waste Generators", composting will be a safe, sanitary and perfectly cost-beneficial solution, if not **the** solution, to reduce waste. This omission means, however, that composting facilities other than those for leaf and yard waste would not benefit from the streamlined approval process that the regulations envisage for such facilities.

On the positive side, Canada would appear to be well positioned to design, build and run either municipal or private composting plants. Companies with experience both in Europe and the United States have established affiliates or subsidiaries in Canada and several provincial research institutes and universities are establishing significant research programs geared towards using compost technology to solve specific waste problems. Ortech International is a good example of that new expertise.

In addition, there exists a diversified private-sector waste management infrastructure that is already serving Canada's industrial, commercial and institutional sector. The challenge will be to bring that existing expertise and infrastructure together with those major entities that are being confronted with monumental waste disposal problems, be they cities, companies or institutions.

How is composting likely to develop in Canada? Cities that are contemplating the introduction of municipal compost systems for residential waste typically start with making separate collections for yard waste (which can be easily composted in open windrows), to be followed by food waste composting systems, and culminating in combined yard-waste, food waste, other organics and even sewage sludge, sometimes referred to as "co-composting". Although the proposed provincial regulations endorse and confirm the importance of composting systems for leaves and yard waste, the regulations are silent on more elaborate systems. Municipalities, however, are thinking of moving beyond yard waste, as witness for instance the elaborate plans that exist for a fuel-scale composting facility in Hamilton-Wentworth or Guelph. The draft Ontario regulations (p.22) do anticipate, however, that municipal source-separation programs will eventually include organics.

As for ICI waste, establishments in Ontario will be requested -as a first step- to ensure source separation of a number of priority materials, but food waste and other organic wastes are not included in the initial mandatory procedures. Yet, this is clearly an area where great strides can be made in waste reduction, where appropriate Canadian technologies can be developed and where new partnership between waste makers and waste takers can be forged.

In this process, one can visualize a cooperative of hospitals, perhaps in combination with restaurants and educational institutions, to bring about the construction and operation of composting systems dedicated to the transformation of at least 40 percent and potentially up to 60 percent of their waste stream to a useful and environmentally friendly product.

I think Associations have an important role to play in forging these new partnerships. Associations such as yours and Associations such mine; The Composting Council of Canada.

The Composting Council of Canada is a federally incorporated non-profit organization which seeks to support municipal and industrial composting systems, to ensure realistic compost quality standards, to develop markets for compost and to educate the public. Its current membership of 62 consists of 23 corporate members, 8 universities and non-profit organizations, 10 so-called first-tier municipalities, 5 regional municipalities, 7 governments (including Environment Canada) and 9 individual members.

The Corporate members represent companies that manufacture products that could be composted, companies that manufacture composting equipment, companies that design and operate composting systems and companies that use compost. The Council, which will have its inaugural meeting in Toronto on October 28, is a broadly based coalition of interests which intends to become a strong and constructive force with respect to solving Canada's waste management problems.

To conclude: The purpose of my speech was:

- to introduce to you the notion of composting as a meaningful and cost-effective waste-management tool;
- to outline the relevancy of composting to municipal waste problems, be they residential, industrial, commercial or institutional;

- To identify some important new potential linkages between waste generators and waste managers;
- to suggest issues on which members of your Association would be well advised to cooperate with each other and with their clients, and finally,
- to offer on behalf of the Composting Council of Canada, our full cooperation in addressing those new and pressing problems.

NOT IN MY BACKYARD

Successful Siting of Solid Waste Disposal Facilities
Regional Greenfield Sites

By

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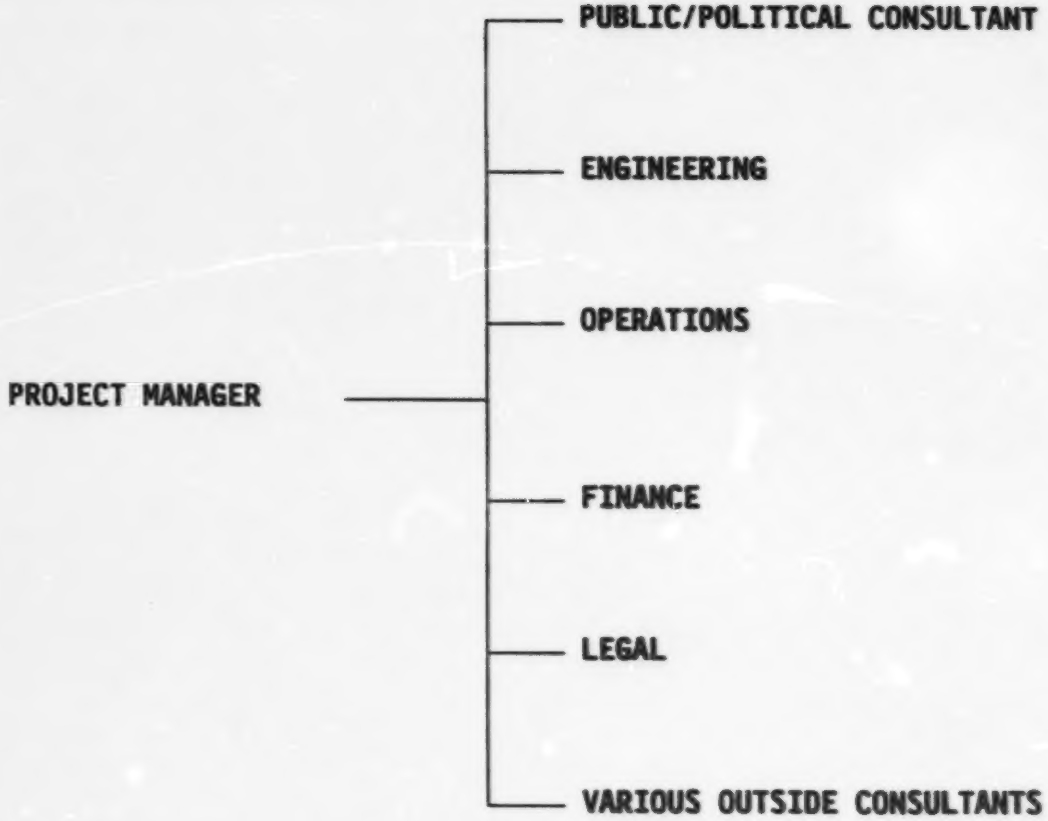
LANDFILL SITING OVERVIEW

1. **Project Staffing**
2. **Site Selection - Preliminary Evaluation**
3. **Benefits to Host Communities/Residents**
4. **Establish Public Support/Communications**
5. **Public Opinion Categories**
6. **Obstacles to Siting**
7. **Site Selection - Specific Evaluation**
8. **Final Phase**

PROJECT STAFFING



PROJECT MANAGER

PUBLIC/POLITICAL CONSULTANT

ENGINEERING

OPERATIONS

FINANCE

LEGAL

VARIOUS OUTSIDE CONSULTANTS

SITE SELECTION
PRELIMINARY EVALUATION

1. USGS QUADRANGLE SHEETS
2. AREA MAPS AND POPULATION DENSITY
3. AREA ZONING AND LAND USES
4. PROPERTY MAPS AND LEGAL DESCRIPTION
5. ROAD SYSTEMS, TRAFFIC PATTERNS, AVAILABLE UTILITIES
6. FLOOD PLAIN MAPS
7. RIGHT-OF-WAYS, EASEMENTS AND MINERAL RIGHTS
8. GENERAL AND SITE SPECIFIC GROUNDWATER DATA
9. GENERAL AND SITE SPECIFIC SOILS DATA
10. AREA DRINKING WATER SUPPLY
11. ARCHAEOLOGICAL/ECOLOGICAL STUDIES
12. NATIONAL WETLANDS INVENTORY MAPS

BENEFITS
HOST COMMUNITIES/RESIDENTS

1. WASTE DISPOSAL SERVICES
   - A. No Cost
   - B. Reduced Cost
2. HOST FEES TO COMMUNITY
3. ADDITIONAL TAX REVENUE
4. AREA ROAD IMPROVEMENTS
5. EMPLOYMENT OPPORTUNITIES
6. PROPERTY VALUE COMPENSATION
   - A. Protection Against Lost Future Value
7. PRIVATE WATER WELL COMPENSATION
   - A. Replacement
   - B. Monitoring/Testing
8. PHYSICAL/VISUAL COMPENSATION
   - A. Fencing
   - B. Screening
   - C. Gas Control
   - D. Pest Control
   - E. Contingency Plan and Fund

BENEFITS
HOST COMMUNITIES/RESIDENTS

9. EFFORTS TO CONTROL/LIMIT NUISANCES

A. Dust Control

B. Blowing Litter Control

C. Noise Reduction

D. Vector Control

E. Odor Control

10. COMMUNITY IMPROVEMENT PROJECTS

A. Recreational/Sports Areas

B. Parks

C. Bike Paths/Nature Areas

D. School Improvements

E. Community Group Sponsorship

11. RECYCLING PROGRAM

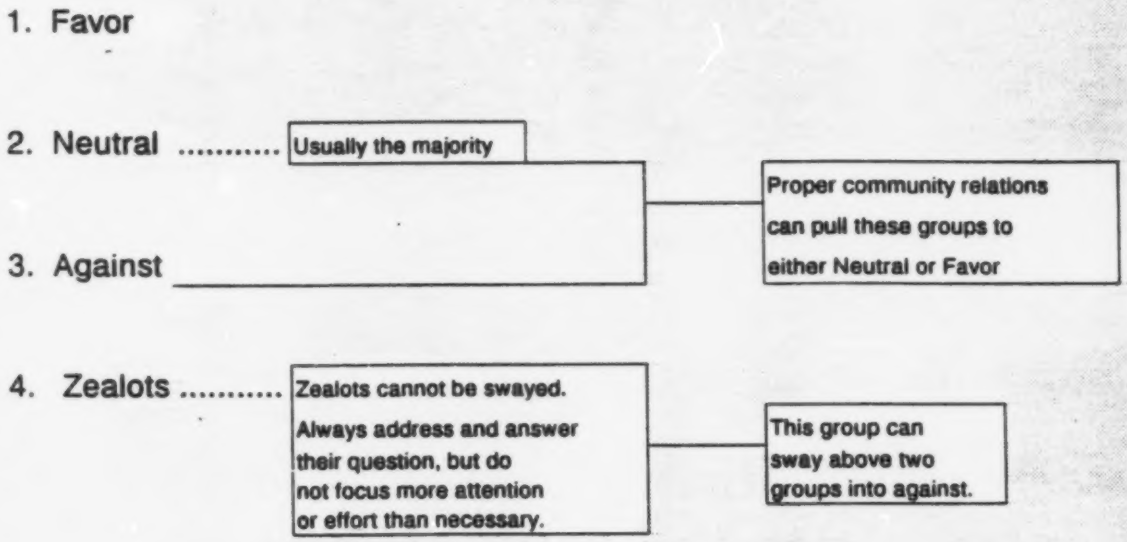
A. Extended Life Of Site

B. Jobs

ESTABLISH
PUBLIC SUPPORT/COMMUNICATIONS

1. ADVERTISING
    - A. PAPER
    - B. MAILINGS
    - C. RADIO
    - D. TELEVISION
    - E. VIDEOS
    - F. HANDOUTS/PAMPHLETS
2. PUBLIC INFORMATION MEETINGS OR LOCATIONS
    - A. ALLOW EARLY AND MEANINGFUL CITIZEN INPUT
    - B. PROVIDE INFORMAL SETTING TO EXCHANGE IDEAS AND CONCERNS
    - C. ALLOW NONTECHNICAL ISSUES TO BE FULLY ADDRESSED
    - D. POLL/FOCUS GROUPS
    - E. SITE TOURS
    - F. ONE TO ONE DISCUSSIONS WITH KEY INDIVIDUALS OR GROUPS
3. COMMUNICATE WITH LOCAL OFFICIALS/MEDIA
4. PROVIDE COMPLETE AND CONSISTENT INFORMATION
5. PROACTIVE VS. REACTIVE
6. MONITOR SUCCESS OR FAILURE
7. ESTABLISH LOCAL CITIZEN ADVISORY GROUP

PUBLIC OPINION CATEGORIES



1. Favor
2. Neutral .... Usually the majority
3. Against
4. Zealots .... Zealots cannot be swayed.

Proper community relations can pull these groups to either Neutral or Favor

Always address and answer their question, but do not focus more attention or effort than necessary.

This group can sway above two groups into against.

OBSTACLES TO SITING

1. PROPERTY ACQUISITION
2. LOCAL PERMITS
    - A. ZONING
    - B. CONDITIONAL USE
    - C. PRIVATE RESTRICTIONS
3. TECHNICAL ISSUES
    - A. HYDROGEOLOGY
    - B. GEOLOGY
    - C. ARCHAEOLOGIC/ECOLOGIC CONDITIONS
4. ENVIRONMENTAL IMPACT ASSESSMENT
5. STATE/FEDERAL RESTRICTIONS
    - A. LOCATION/AIRPORTS
    - B. WETLANDS
    - C. SOLE SOURCE AQUIFERS
    - D. RECHARGE ZONES
    - E. NATIONAL REGISTER
    - F. ENDANGERED/THREATENED SPECIES
    - G. CRITICAL HABITAT

OBSTACLES TO SITING

6. LEGAL OPPOSITION TO DECISIONS
    - A. CONSERVATION
    - B. HEALTH
    - C. SAFETY
    - D. PROPER LAND USE
7. FINANCIAL STAYING POWER
    - A. MARKET FLUCTUATIONS
    - B. POTENTIAL REMEDIATION
    - C. CLOSURE COST
    - D. INSURANCE/BONDING REQUIREMENTS
8. PROPERTY VALUE IMPACT
9. NEIGHBORHOOD IMAGE
10. LOCAL NUISANCE LAWS
11. LACK OF CONFIDENCE IN OWNER/OPERATOR

SITE SELECTION
SPECIFIC EVALUATION

1. ARCHAEOLOGIC EVALUATION
2. ECOLOGIC (PLANTS/ANIMAL/HABITAT) EVALUATION
3. WETLANDS DELINEATION
4. PRELIMINARY HYDROGEOLOGIC/GEOLOGIC STUDIES
5. CONCEPTUAL LANDFILL DESIGN
6. PUBLIC RELATIONS
    - A. ADVERTISEMENTS
    - B. PUBLIC MEETINGS
    - C. SURVEYS OR FOCUS GROUPS
    - D. SITE TOURS

FINAL PHASE

1. PLANNING/ZONING COMMITTEE HEARING

2. ZONING APPROVAL/PUBLIC HEARING

3. START PERMITTING PROCESS

AN EVALUATION OF MSW MANAGEMENT IN CALGARY, ALBERTA

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Abstract

The management of municipal solid waste in an environmentally safe and economically efficient manner has become a growing concern in Canada. Poor management and overburdened landfills have become increasingly serious problems in many cities, resulting in the need for comprehensive and objective evaluations of current practices to direct and improve future initiatives.

Impending federal waste reduction legislation requires substantial reductions in the amount of refuse landfilled by 2000. Municipalities relying heavily upon landfilling for waste disposal must investigate techniques for improving effectiveness and efficiency of current waste management procedures, and examine alternative methods for managing municipal solid waste.

Calgary, Alberta employs sanitary landfilling exclusively to fulfill municipal solid waste disposal requirements in the City. Landfill operations appear to pose little threat of environmental pollution. However, there are outstanding issues surrounding compliance with provincial waste legislation which require further attention. Calgary is investigating alternative methods of managing MSW in the City, however, they do not lead the country in progressive waste management practices. Furthermore, it appears that Calgary's Sanitation Department should investigate more thoroughly the composition of the municipal waste stream in the City prior to implementing waste management options.

INTRODUCTION

Municipal solid waste (MSW) is defined as residential and commercial discards such as food scraps, grass and shrub trimmings, bottles, cans, tires, paper, packaging, wood, and metal (Rathje, 1989). There are numerous reasons for studying MSW. In today's society there is growing concern about the finite quantity of natural resources and the environmental implications of disposing of MSW indiscriminately. Canadians are among the greatest per capita generators of waste in the world, producing over 600 kg/person/year (Environment Canada, 1991a). An investigation of the distribution of different waste types indicates that residential and commercial wastes compose over half of the solid waste stream in Canada (Environment Canada, 1991b). Furthermore, MSW is produced and disposed of in urban areas characterized typically by population pressures and growing demand for land. Public protest and environmental problems are exacerbated in high density cities that manage MSW inadequately.

Municipal solid waste traditionally has been managed by a complement of engineers, economists, biologists, and municipal planners. However, it is becoming increasingly apparent that inadequate waste management practices have deleterious effects on land, air, and water resources. Environmental pollution problems strain fiscal resources and jeopardize the health of the planet and its inhabitants. Waste management is more than a technical exercise, rather, it involves a complex combination of political, social, economic, and environmental factors. There is a growing recognition of the interdisciplinary nature of waste management and the need to address problems from a holistic perspective offered by environmental scientists such as geographers and resource managers.

The impetus for government and individuals to become increasingly involved in decisions regarding the future of municipal solid waste (MSW) management practices is a result of an environmental imperative to preserve the quality and quantity of finite natural resources from the threat of pollution and overutilization. Traditionally, waste managers were required to report volume statistics and the cost of waste disposal to justify continued financial support from municipal and provincial offices. However, as a result of more stringent legislation and public pressure, municipal waste management departments, such as Calgary's, are now expected to justify employing particular waste management options. Landfilling and incineration are no longer seen as the panacea of waste management, rather, they appear to squander natural resources and present pollution risks which are often deemed unmanageable. Waste managers must demonstrate that current MSW management strategies are both effective and efficient *and* ensure limited environmental degradation.

Current municipal waste management practices will eventually be subject to either an internal or external evaluation process to quantitatively measure *effectiveness* and *efficiency*. In this paper, MSW management in Calgary is investigated by reviewing relevant waste management literature and investigating pertinent provincial and municipal legislation. Waste management issues distinct to Calgary are addressed by conducting site visits and interviewing waste management workers (Peddle, 1991).

During the process of evaluating municipal solid waste management in Calgary, several problems relating to information access were experienced. Difficulties included limited access to landfill facilities and waste management documents. Restricted access to waste management documents and incomplete files greatly inhibited a quantitative evaluation of MSW management in Calgary. It was possible to gather sufficient information to complete an evaluation of MSW management in Calgary, however, a rigorous application of evaluation research methodology was deemed impractical because fundamental background information was largely unattainable. Where access permitted, a modified, more qualitative assessment of the 'effectiveness and efficiency' of Calgary's waste management department was accomplished utilizing available data, and relying upon site visits and interviews with City employees.

MUNICIPAL SOLID WASTE MANAGEMENT IN CALGARY

During the late 1960s and early 1970s the City of Calgary acquired four new landfill sites. This era marked the end of dumps and landfills in Calgary, and the initiation of sanitary landfill technology as the preferred method of disposing of municipal solid waste. The City of Calgary currently owns and operates three sanitary landfills and one dry disposal site (City of Calgary, 1989 and City of Calgary, 1988), and relies exclusively on sanitary landfilling for fulfilling Calgary's MSW disposal needs.

In addition to City-operated sanitary landfills, Browning Ferris Industries (B.F.I.) operates a sanitary landfill located approximately 3 km of the City.

City of Calgary Waste Management Objectives

The prime objective of the City of Calgary's Sanitation Division is to provide the residents of Calgary with an effective and efficient waste collection and disposal system which complies with City Bylaws and Provincial Government Regulations (City of Calgary, 1981). In addition, they aim to provide continuing input into the development of improved waste storage and handling techniques, and to investigate the most cost effective disposal capability for the entire waste stream (Griffiths, 1991, pers. comm.).

The Sanitation Division is responsible for collecting the waste generated by all single dwelling houses and to collect no more than 10 percent of the commercial and industrial establishments, as outlined by the City of Calgary Waste By-Law 13M82 (City of Calgary, 1982). It is also the Sanitation Division's responsibility to dispose of all solid waste which is delivered by private individuals to City-operated sanitary landfill facilities (City of Calgary, 1981).

Legislation

There are a myriad of government Acts and municipal ByLaws which determine the standards of procedure for municipal solid waste management in Calgary. The two most significant pieces of legislation are the Government of Alberta Public Health Act and the City of Calgary Waste ByLaw 13M82. The Public Health Act (Government of Alberta, 1985) outlines site selection criteria, landfill design, and the nature of materials which can be legally disposed of at a landfill. The City of Calgary Waste ByLaw 13M82 (City of Calgary, 1982) summarizes the nature and scope of specific landfill operations within the City. The salient legislative orders contained in the Public Health Act and the City of Calgary Waste ByLaw 13M82 are discussed briefly to provide the necessary background to determine whether municipal solid waste management in Calgary is complying with these two significant pieces of legislation.

In Alberta, two types of land disposal methods are permitted - *modified* and *sanitary* landfills (Government of Alberta, 1985). Sanitary landfills service municipalities, such as Calgary, with a population greater than 10,000 (Government of Alberta, 1985). Sanitary landfills must be constructed according to strict engineering design parameters (Peddle, 1991). Sanitary landfills also are fenced to minimize problems associated with windblown litter. Lastly, sanitary landfills have supervised operating hours to monitor and control waste disposal activities. Generally, sanitary landfills are well maintained because they are in urban areas and subject to more frequent inspection than modified landfills (MacKenzie, 1985).

In addition to designating modified and sanitary landfill operating procedures, the Public Health Act states every municipality is responsible for the provision, operation, and supervision of one or more waste management facilities for the safe and sanitary disposal of all waste created within the municipality (Government of Alberta, 1985).

Lastly, the Public Health Act prohibits the development or operation of a landfill within 450 m of any hospital, restaurant, or occupied dwelling used for human habitation (Government of Alberta, 1985). Furthermore, a municipality must submit detailed site reports outlining topographic, pedologic, and hydrologic conditions of a site being considered for sanitary landfilling.

The City of Calgary Waste ByLaw 13M82 restricts the City of Calgary Sanitation Department to collecting 10 percent of commercial refuse produced within the City (City of Calgary, 1982). Remaining commercial garbage is collected by private waste haulers such as B.F.I., Laidlaw, and Waste Management (Griffiths, 1991, pers. comm.).

Sanitary Landfill Operations

All of Calgary's sanitary landfills, including the privately owned and operated B.F.I. facility, use the *trench* method of landfilling, which is typically used when groundwater is far from the surface and the soil is more than six feet deep. A trench is excavated to produce a landfill approximately 3 m to 4 m deep, 75 m wide, and 450 m to 600 m long (Tavernier, 1991, pers. comm.). A three metre natural clay liner is installed at the base of the trench and compacted to inhibit leachate seepage (Brunner and Keller, 1980). Excavated soil is stockpiled and later used as fill between cells and to cover the garbage face.

Garbage is unloaded at the toe of the slope and compacted throughout the day using a trashmaster vehicle which reportedly compacts one tonne of garbage into one cubic metre (Van Rijan, 1991, pers. comm.). Refuse is compacted to a one metre height and then covered with six inches to one foot of clean fill. Each cell is covered with 15 to 30 cm of soil and subsequently compacted. A compacted and covered lift constitutes a 'cell'. A series of contiguous cells produces a 'lift'. The garbage face is covered with 30 cm of soil twice a day in the summer, and once a week in the winter due to the decreased volume of garbage going into the landfill in the winter (Van Rijan, 1991, pers. comm.).

There are typically three to four lifts in a trench. Once the trench is full, approximately 1 m of clay and 30 cm of loam are spread and compacted over the top of the completed trench. The area is then graded and hydroseeded to produce a reclaimed area similar in appearance to a grassy field.

Landfills in Calgary have supervised operating hours which facilitate increased control of the type of waste disposed of by private citizens and commercial waste haulers, while providing the citizens of Calgary with convenient access to waste management facilities.

Landfill sites have weigh scales at the main gate to record the quantity of waste disposed . A vehicle is weighed as it enters the landfill compound and again before leaving the facility, and subsequently charged for the quantity disposed. Citizens of Calgary are permitted 200 kg of free disposal per week; disposal above this weight is charged at the regular commercial disposal rate of $10.60/tonne. Disposal of dry rubble and industrial wastes at the dry disposal site is charged at $6.13/tonne (City of Calgary, 1989).

In addition to the regular sanitary landfilling of municipal wastes at each of the City's landfills, there are a number of other waste disposal services provided by the City of Calgary. For instance, one of the sanitary landfills operates a small dead animal pit where road kill, laboratory animals, and family pets can be disposed of safely. Animals are placed in a pit similar in design to a miniature landfill trench, and covered with 6-8 cm of lime to hasten decomposition. Approximately 10 cm of soil are spread over the pit daily to discourage coyotes, dogs, and rodents from scavenging (McKinnon, 1991, pers. comm.).

In 1989, scrap tires from three landfill facilities were transported to a sanitary landfill located in southeast Calgary (City of Calgary, 1989). Tires were placed directly onto the ground and separated by dirt berms. Tires have been stockpiled at a separate section of the landfill in response to concerns regarding the threat of a potential fire hazard. Transporting tires to this site localized the potential fire hazard. Furthermore, this site is also relatively far from residential developments, and is therefore deemed a preferable location for disposing of scrap tires (Boone, 1991, pers. comm.).

The City of Calgary installed its first leachate monitoring system at one of its sanitary landfills in 1990. Drainage pipes were placed at the base of a new, unused landfill trench, and then covered with the clay liner system typically used in sanitary landfilling. The exposed end of the pipe will be monitored for effluent. If effluent is produced, samples will be collected and tested. Samples would be analyzed to determine chemical composition and decide whether nearby ground and surface water is being contaminated (Boone, 1991, pers. comm.).

Recycling Efforts

The City of Calgary has initiated a number of recycling and waste diversion projects which are practiced at all of their landfills. For instance, in late 1989 the City collected approximately half of all of the discarded Christmas trees in Calgary. Trees were stockpiled and the City plans to have them chipped for use as a decorative ground cover in picnic areas, and as an inexpensive method of lining bicycle paths (Tavernier, 1991, pers. comm.).

The City is also working with various companies to recycle oil, propane tanks, batteries, mattresses, and white goods such as water heaters, washers, and bathtubs. These articles are collected at each landfill site until a sufficient quantity has accumulated, at which time the appropriate recycling company is called to collect the goods (Van Rijan, 1991, pers. comm.).

Every spring the City organizes a "toxic round up day" when citizens can dispose of leftover paint, solvents, aerosols, batteries, oil and various other hazardous and industrial wastes. The City subsequently separates the hazardous and nonhazardous wastes. Nonhazardous wastes are either landfilled or recycled, and hazardous wastes are placed in the Chem-Security hazardous waste transfer station for subsequent transportation to Swan Hills (Boone, 1991, pers. comm.).

The City of Calgary has undertaken a residential recycling pilot project. The Engineering Department of the Sanitation Division has designed a pilot program based on two types of collection systems - curbside (blue box) and drop-off (depot). The two collection methods are presently being tested in selected residential communities in the City to determine which method of collection is most appropriate for the future expansion of the City recycling program (City of Calgary, 1990).

In addition to the recycling pilot project, the City began a pilot leaf composting project at one of its sanitary landfill in 1989 (Boone, 1991, pers. comm.). Leaves are composted in a separate trench using windrows approximately 4.2 m wide and 2.1 m high. Leaves are turned once a month and watered as needed; bulking agents were not added (Boone, 1991, pers. comm.).

Municipal Solid Waste Stream Composition

Finally, a few notes on waste stream composition in Calgary provide the necessary background for demonstrating the need for improved initiatives in this area. Municipal solid waste (MSW) streams are composed of a complex combination of heterogeneous materials including organics, plastics, metals, paper, glass, rubber, and wood which vary depending on local geographic and socio-economic conditions (Gore and Storrie Ltd., 1991). Contemporary waste management strategies, which include waste reduction, recycling, composting, incineration, and landfilling, must be sensitive to variations in waste stream composition to ensure the best combination of waste management technologies are employed. Managing MSW effectively requires a quantitative understanding of the relative contribution of various components to the municipal solid waste stream. It is difficult to manage solid waste or implement changes to current waste management practices if the precise composition of the waste stream has not been determined. For instance, implementing waste reduction and recycling programs is of growing importance to municipalities which currently face landfill shortages, and of concern also to communities, such as Calgary, sensitive to problems associated with excessive waste generation. Prior to implementing changes to waste management practices, which may aim to reduce waste or increase efficiency of current management techniques, it is essential for waste managers to understand the actual composition of waste components in their community's waste stream and size facilities accordingly (Peddle, 1991).

EVALUATION OF MUNICIPAL SOLID WASTE MANAGEMENT IN CALGARY

This section evaluates municipal solid waste (MSW) management in Calgary by assessing *effectiveness* and *efficiency*. Investigating effectiveness is accomplished by comparing Sanitation Department objectives with the manifestation of current waste management programs to determine whether the City's mandate accomplishes desired waste management goals. In addition, compliance with pertinent waste legislation is investigated to determine if current waste management objectives are congruent with legislation.

Efficiency is investigated by assessing issues and problems associated with implementing existing waste management practices. Issues discussed include long-term environmental integrity, working conditions, and attitudes about the future of MSW management in Calgary. In addition, issues surrounding MSW stream composition in Calgary are discussed.

Legislative Compliance

With regards to the City complying with Government of Alberta's Public Health Act (Government of Alberta, 1985), two points are worthy of mention. Firstly, Alberta Environment handled case files on municipal waste management in Alberta until 1989. Files included site information, requests for permission to operate a waste management facility, scope of operations, and problems relating to maintaining waste management facilities. After 1989, municipal Health Service departments were charged with the responsibility of maintaining files for their respective cities. After visiting and reviewing waste management files at Calgary Health Services, information regarding municipal solid waste management was absent or deemed incomplete because pertinent information regarding landfill site description and environmental monitoring was not present.

Detailed information regarding the hydrologic, pedologic, and topographic conditions of a potential sanitary landfill site must be filed with the request to operate a waste management facility in Alberta. Site description information could not be located for any of the City's landfill facilities. In addition, the City would not permit the collection of samples from landfill sites to determine soil type or stratigraphic sequences. Therefore, an evaluation of whether the City of Calgary located sanitary landfills appropriately cannot be completed.

When questioned about inadequate files at Calgary Health Services, the author was informed files were in the same condition as received from Alberta Environment (Carlson, 1991, pers. comm.). As a result of the recent acquisition of waste management files, Calgary Health Services is only now updating files and investigating the location of missing information.

The second issue regarding the City's compliance with the regulations set forth by the Public Health Act regards the location of waste management facilities in reference to houses and restaurants. The Public Health Act prohibits the development of operation of a sanitary landfill within 450 m of restaurants and inhabited dwellings. When Calgary developed its four landfills, the 450 m buffer was intact. However, subsequent commercial and residential development has expanded into the buffer zone because reciprocity of the distance restriction is not expected.

As a result of continued encroachment of residential and commercial developments within their buffer areas, two of Calgary's landfills are in direct violation of the Public Health Act. When questioned about this infraction, the City stated the original intent of the legislation did not include provisions regarding urban development subsequent to landfill construction (Griffiths, 1991, pers. comm.).

According to Calgary Health Services, the City should have included the 450 m buffer within the perimeter of the landfill rather than simply establishing the facilities 450 m away from commercial and residential developments (Carlson, 1991, pers. comm.). It is difficult to determine whether action will be taken to investigate this problem, however, as homes and businesses come in closer proximity to landfill operations, there may be complaints from homeowners and business people about odors and traffic flow, and increased concerns regarding potential pollution problems.

The City has mitigated this potential problem by constructing initial disposal trenches at each of its landfill facilities close to the perimeter of the site, and subsequently moving towards the middle of the site as each trench is completed, leaving a reclaimed area near the landfill perimeter. When communities develop closer and closer to the landfill, all that is visible is an aesthetically pleasing reclaimed field. The active portion of the landfilling operation lies behind the areas reclaimed. One exception to this 'building-inwards' concept is the dry disposal site. Unfortunately, trench construction began in the center of the landfill and is moving outwards. Nearby communities are quickly approaching and complaints about the perceived unsightliness of the active landfill should be anticipated.

The City of Calgary Waste ByLaw 13M82 restricts the the Sanitation Department to servicing the waste disposal needs of 10 percent of commercial establishments within the City.

Unfortunately, the ByLaw does not specify whether the restriction pertains to 10 percent of commercial establishments or 10 percent of the total volume produced. The Sanitation Department has interpreted the ByLaw to mean the latter. The B.F.I. sanitary landfill receives a majority of the remaining commercial waste produced in Calgary (Griffiths, 1991, pers. comm.). Representatives of B.F.I. were not willing to disclose the volume of commercial waste accepted for disposal at their facility (Michaels, 1991, pers. comm.), thus preventing a full investigation of compliance with the City Waste ByLaw. Without the commercial volume statistics for B.F.I., it is impossible to determine whether the City of Calgary Sanitation Department is collecting only ten percent of the commercial waste produced within the City.

Efficiency of Waste Management in Calgary

In general, the mandate of the Sanitation Department is to provide the citizens of Calgary with a safe and efficient method of disposing of municipal solid waste, and to investigate alternative waste management methods which may increase the efficiency of waste management in the City.

Before proceeding with a discussion of the manifestation of waste management objectives, it is important to note that specific information regarding the policies of intended developments for improved waste management in the City have not been stated formally. Rather, the City reserves the right to investigate alternative waste management options at their discretion.

With regards to providing for the safe disposal of municipal solid waste, three points are worthy of mention. Firstly, the City is faced with a significant windblown litter problem. While compacting refuse disposed in sanitary landfills ultimately decreases windblown litter, uncompacted refuse often lays in trenches a short time before being processed by the trashmaster vehicle. Meanwhile, strong winds associated with Calgary blow litter off the face of the garbage lift. The City has attempted to mitigate this problem by installing 5 m high litter fences at all sanitary landfill sites to inhibit the spread of garbage onto surrounding land. However, fences do not trap all blowing debris, and as a result, litter is deposited on land adjacent to landfills. A problem encountered as a result of windblown litter involves cattle grazing in farm fields adjacent to landfill facilities. Cows eat the litter and may become ill, and possibly die as a result of digestive problems.

In addition to the cattle problem, blowing litter which collects on fences produces unsightly conditions. Summer clean-up crews constantly pick refuse off litter fences and nearby land to improve the visual appearance of landfill facilities. Each day litter is picked up and each day more litter is deposited by the wind. This problem is compounded by the fact the Sanitation Division only receives funding for extra site maintenance in the summer months, during which time seasonal garbage pickers are hired. However, windblown litter is not a seasonal problem, and as a result, during the rest of the year, full time employees are diverted from other important tasks to control the litter nuisance.

Detailing problems associated with windblown litter is not intended to leave the reader with the impression Calgary's sanitary landfills are poorly maintained. Quite the opposite is true. Site visits amply demonstrated landfill sites are not characterized by smelly mounds of unattended garbage typically envisioned by the public. Facilities are maintained in an orderly fashion and are safe and clean, and, often do not have the outward appearance of a landfill until the active area of landfilling is approached.

The production of leachate and subsequent groundwater contamination is considered a serious environmental threat. Leachate production is not a documented problem at landfill facilities in Calgary because of the relatively dry, local climatic conditions. Leachate usually is produced only when buried garbage is saturated with water. Low water table levels, coupled with limited precipitation in Calgary, produce conditions which inhibit leachate development.

Information regarding results of environmental monitoring at landfill facilities was unavailable. Typically, monitoring consists of testing ground and surface water twice a year, and monitoring gas and leachate parameters to determine if a landfill is polluting the environment. Many groundwater monitoring wells are cracked or located in inappropriate locations to test for pollution (Boone, 1991, pers. comm., and Griffiths, 1991, pers. comm.). The City has not submitted an environmental monitoring report of landfill operations in nearly one and a half years (Boone, 1991, pers. comm.). There is no evidence to suggest there are serious pollution problems generated by Calgary's sanitary landfills. However, current environmental monitoring results should be provided to document the environmental safety of landfill operations.

The integrity of sanitary landfills plays an integral role in preventing environmental pollution (Leskiw, 1981). Calgary's sanitary landfills are located on flat to gently rolling land, groundwater levels are low, and the soil or overburden is reportedly more than two metres deep. The trench method of sanitary landfilling is an appropriate choice for handling municipal solid wastes in Calgary because it best suits the various environmental conditions.

In addition, compacting garbage decreases potential fire hazard by using nonflammable soil to form earth barriers between cells of garbage. Domestic refuse is heterogeneous and typically composed of potentially incompatible substances. When such materials combine in a landfill, there is a threat of explosive fires. Landfill fires are difficult to extinguish because contents are volatile and the exact composition of the material causing the fire is unknown. Compacting the refuse further decreases the likelihood of fire by eliminating air spaces between landfilled refuse.

The addition of soil cover, coupled with refuse compaction also decreases odors and windblown litter, and increases pest control. Rodents, insects and birds cannot burrow into compacted garbage to make homes or lay eggs. In addition, compaction decreases the likelihood of vermin eating garbage, which can subsequently spread diseases such as salmonella and rabies when vermin come in contact with animals and humans. While few rodents and birds were witnessed at sanitary landfill facilities operated by the City of Calgary, many seagulls were observed hovering over active landfill trenches at the B.F.I. facility. This may be a result of inadequate cover material or infrequent compaction of incoming refuse.

The texture of soil chosen to line and cover landfill cells determines the degree of drainage and structural stability within the landfill (Brunner and Keller, 1980). Soil with a texture of sand offers poor protection against surface water percolation and permits an uncontrolled release of landfill gases. The City of Calgary uses clay-textured soil to line and cover landfills. Clay provides an impermeable liner at the base of landfill trenches which effectively encapsulates overlying refuse. Used as a cover, clay is excellent for minimizing moisture from entering the fill and helps reduce the emergence of flies. Clay also controls unregulated release of methane gases, and provides an excellent base for reclaiming the site with vegetation (Brunner and Keller, 1980).

Many cities are beginning to use synthetic liners rather than natural clay liners to secure their landfills and increase environmental safety. Synthetic liners are available in a variety of materials and thicknesses to accommodate even the most demanding climatic conditions. However, landfill liners are very expensive and are often torn or cracked during installation. These factors, combined with the fact the natural clay liner system currently employed by the City is thought to pose no environmental threat, has lead the City to reject the installation of synthetic liners.

A significant problem associated with landfilling is the production of methane gas, an odorless, colourless, flammable gas. Methane is a by-product of anaerobic decomposition which typifies landfill conditions. When released at the surface, methane tends to collect around buildings and in basements. An accumulation of even five percent methane is explosive when methane seeps into basements of houses nearby and is ignited by furnaces (Brunner and Keller, 1980). The City of Calgary has mitigated this problem by installing methane vents which are essentially pipes inserted through the relatively impermeable top cover of the landfill. Vents permit a slow, safe, release of methane gas which virtually eliminates the threat of methane accumulation.

The City of Calgary has developed three sanitary landfill sites and one dry disposal facility rather than using fewer sites and incorporating transfer stations into its waste management system.

In the latter system, garbage is collected as usual and brought to a central depot location where there is a large metal container. Waste is dumped into the container until it is full, at which time the container is attached to a transport truck and hauled to the nearest landfill facility. The number of depots used is dependent upon the size of the city. Waste transfer stations currently are used in Halifax, Toronto, and Edmonton where costs associated with waste collection are deemed prohibitive (MacKenzie, 1985). Arguably, transport trucks have a greater capacity for hauling refuse than smaller refuse collection vehicles used for municipal waste collection. The City of Calgary contends having four strategically located sanitary landfill sites throughout the City actually decreases the amount of time collection vehicles are enroute to landfill sites and facilitates a shorter and quicker round trip between collecting and disposing of garbage.

In addition, the City argues the configuration of landfills provides citizens of Calgary with greater access to disposal facilities which eliminates the need for individuals to travel long distances to dispose of wastes. It is difficult to determine which of the waste transfer stations or multiple landfill facilities is the most economically viable means of managing municipal solid waste. Evaluating optimal truck assignment for refuse collection often involves complicated and ambiguous economic and statistical manipulations (Jones, 1976 and Wirasinghe and Waters, 1983).

Various recycling efforts and services offered by the City of Calgary are well organized and provide Calgarians with a way of disposing of bulky and hazardous wastes safely. Calgary also has undertaken a residential recycling pilot project to determine the most suitable system for collecting recyclables in the City. In addition, Calgary composts leaves at the one if its landfills, reportedly employing windrows. During a visit to this, leaves were laying in long horizontal rows which do not conform to windrow composting standards. Furthermore, leaves did not appear to have undergone decomposition and material reduction. Problems associated with inadequate aeration and watering may have inhibited the microbial activity necessary to decompose organic matter.

Often there is an inverse relationship between the amount of landfill space available and the conscientious application and implementation of waste diversion and reduction programs (ie. the more landfill space available the less likely a municipality is to consider recycling as a waste management method). Calgary has approximately fifty years of landfill space remaining based on current waste disposal trends (Griffiths, 1991, pers. comm.). As a result of having long-term landfill resources, the City believes it has ample time to evaluate alternative waste management techniques. The City of Calgary is slowly investigating alternative waste management methods, which will be assessed and possibly implemented based on merits of environmental safety and waste minimization. However, Calgary may not have the luxury of delaying full-scale recycling and composting programs. As discussed previously, impending waste reduction legislation will require substantial waste minimization and diversion of wastes from landfills.

The B.F.I. sanitary landfill is conspicuously absent from the preceding evaluation of municipal solid waste management in Calgary because access to facility records and operational procedures was prohibited. Waste managers at B.F.I. claim they adhere to all provincial and municipal waste management regulations, and, in addition, to US EPA guidelines. They contend landfill operations at the B.F.I. site are safer than at City landfills. However, no evidence was provided to demonstrate this superiority. B.F.I. is a privately owned and operated landfill with a policy to not disclose information regarding the nature of its operations.

The City of Calgary Sanitation Department has not undertaken a waste stream composition study to characterize waste stream dynamics in the City, rather, it relies upon data compiled by Franklin Associates Ltd. (1989) (Griffiths, 1991, pers. comm.). The study calculated waste stream composition by excavating and weighing waste materials deposited in an Arizona land disposal site which represented 1986 landfill conditions (Franklin Associates Ltd., 1989). According to the data, paper, plastics, and metal components comprise a majority of the municipal solid waste stream. Peddle (1991) discusses problems associated with Calgary utilizing waste stream analyses conducted by another city. Problems include sampling design, demographics, socio-economics, regional variations, and the year of the study.

Calgary might be expected to demonstrate municipal solid waste (MSW) stream characteristics similar to Edmonton, Alberta because both cities have comparable demographics and socio-economic conditions (Free, 1985). However, significant variations have been reported between the paper, plastic, and organic components in Edmonton's and Calgary's municipal solid waste stream (Peddle, 1991). It is possible differences exist between the industrial base of the two cities, however MSW stream composition studies do not include industrial wastes, therefore this is not the cause of waste stream variation between Calgary and Edmonton. Sampling errors or improper research design may have caused spurious variations between the two waste streams. However, Calgary waste managers must investigate and understand the source of the differences to ensure data they are utilizing are accurate.

Municipalities are beginning to utilize waste stream composition studies as instruments for determining appropriate waste management options. Recycling, composting, and incineration facilities can be designed to meet, more exactly, specifications of indigenous waste streams. Waste characterization studies are valuable tools for determining the precise distribution of municipal solid waste components. However, municipalities such as Calgary should be cautious of relying upon waste stream data compiled for other cities, because waste stream characteristics are distorted by variations in sampling design, climate, geography, socio-economics, demographics, and the year the study was conducted.

CONCLUSION

In response to burgeoning waste generation, federal, provincial, and municipal governments in Canada are working in conjunction with concerned businesses and private citizens to understand more fully the dynamics of municipal solid waste and to develop waste reduction objectives (Government of Canada, 1990). The management of MSW in an environmentally safe and economically efficient manner has become a growing concern for many municipalities. Poor waste management and overburdened landfills have become increasingly serious problems, resulting in the need for comprehensive and objective evaluations of current practices to direct and improve future initiatives.

Calgary relies exclusively upon sanitary landfilling to fulfill the waste disposal needs of the City. The City owns and operates three sanitary landfills and one dry disposal facility. Landfill construction appears to conform to engineering standards necessary to minimize environmental degradation. However, the author was unable to investigate landfill integrity or environmental pollution because the collection of soil samples was not permitted, and monitoring information was unavailable.

While landfill construction in Calgary appeared adequate, numerous problems arise when sanitary landfilling is the exclusive waste management technique employed by a municipality. Firstly, landfills consume large quantities of land in or near the city. As population pressures increase, residential dwellings and commercial establishments come in closer contact with landfill operations. If problems arise during landfilling, such as leachate production, fire, or methane emissions, the health and safety of nearby residents is jeopardized.

A second problem of utilizing sanitary landfilling exclusively relates to a movement towards implementing waste minimization legislation in Canada which requires significant reductions in the volume of municipal solid waste landfilled. The federal government is aiming at reducing landfilled waste by 50 percent by 2000 (Government of Canada, 1990). With such a decrease in landfilled waste, it may not be economically feasible for Calgary to operate and maintain four landfills. Furthermore, a restructuring of waste management operations in Calgary will be required to provide for waste disposal techniques not focused on landfilling.

As greater emphasis is given to diverting solid waste from landfills, cities such as Calgary must investigate alternative waste management options such as incineration, recycling, and composting to decrease landfilled wastes and implement waste minimization programs. Prior to adopting new waste management methods, current waste management techniques must be evaluated to determine the appropriate direction of future initiatives.

Regardless of the method employed to manage municipal solid waste in the future, natural resources are consumed. Raw materials are required to manufacture consumer goods. Air and land pollution, related to natural resource extraction, seriously jeopardize the quality of our environment. Vast tracts of land are required to conduct the traditional land disposal of wastes. The process of producing, consuming, and disposing of primary and secondary resources requires sound waste management to ensure environmental regulations are suitable to protect and maintain the quality of our planet for future generations.

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Expansion of the Hillsboro, Oregon, Landfill: Creating Opportunities to Serve the Public Good

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Introduction and Background

The Hillsboro Landfill is located in the Tualatin Valley, adjacent to the City of Hillsboro, Oregon, in the Portland metropolitan area. The site has been used for solid waste disposal since the early 1960s and was purchased and taken over by the current owner in 1983. The facility is currently permitted to accept construction and demolition wastes, land-clearing debris, selected loads of contaminated soils, and asbestos-containing wastes.

The solid waste management system serving the Metro area is based on disposal of municipal solid waste at a regional landfill 140 miles east of Portland, in the dry rainshadow of the Cascades. Administered by the Metropolitan Service District (Metro), the system also relies on continued functioning of the region's only two remaining demolition waste landfills to avoid long-haul of this waste.

Typical of older "wet-bottom" landfills in the high-rainfall areas of western Oregon, the original Hillsboro landfill facility had no leachate collection system. Solid waste was originally used to fill low areas on the site in an uncontrolled fashion. A low, earthen dike had been placed along the toe of the landfill to protect it from flood waters.

In 1987, the landfill owner approached CH2M HILL for assistance in solving the problems he had inherited with the landfill. The landfill was nearing capacity and his primary interests at this point were to close the landfill in an environmentally sound manner and avoid impacts on nearby wetland areas.

An inspection of the landfill indicated that the existing containment dike was inadequate to protect the landfill from a major flood and had been placed on unstable peat-like soils. The dike would require relocation on stable soils further into the flood plain to provide adequate protection and would have to be properly engineered to meet Oregon Department of Environmental Quality (DEQ) requirements. Approximately 250,000 cubic yards of material would be needed for dike replacement and to meet final cover requirements.

Although initially appearing to be major constraints for the closure project, these conditions eventually began to be seen as opportunities to manage and enhance the landfill and to use the land for multiple purposes. By responding to several needs voiced by agencies and the public, the landfill operator has recently received agency approval for the first phase of his operations plan, which calls for phased expansion through the next 20 years. This paper provides a case history of the project to date.

Project Setting

The landfill lies in a portion of the Tualatin Valley historically known as Jackson Bottom, approximately 20 miles west of the City of Portland. The economy in the valley is in rapid transition from a rural, farm-based economy to an urban-centered one, with the electronics industry playing an important role. Upland areas continue to be developed with residential land uses; most low-lying areas in the flood plain have been converted to agriculture either for row crops or for single-species forage. Portions of these areas, which are seasonally flooded, are considered wetlands under federal wetland delineation criteria.

Jackson Bottom has therefore suffered a significant loss of wildlife habitat diversity during the past several years. Reestablishing this diversity through enhancement of existing wetlands and creation of new wetlands is a primary goal of local resource agencies, as identified in adopted land use and resource master plans.

The Tualatin River, which drains the valley, is a low-gradient, sluggish waterway. It has been subject to considerable water quality degradation, especially from high levels of nitrogen and phosphorus compounds in the summer months, which lead to downstream eutrophication problems. Although most point sources of contamination have been identified and sufficiently controlled, the nonpoint sources generated over large areas are, by their nature, more difficult to control and therefore remain mostly unabated. Improved control and treatment of this urban and agricultural runoff has become a focus for resource agencies and environmental groups in the region.

The landfill lies on county land along the border with the City of Hillsboro. Surrounding land uses include the Tualatin River, agricultural, rural residential, greenhouses, and newer suburban residential. Residential uses, primarily those in the subdivision along the northeast border of the site, pose the most potential land use conflicts with the landfill. Although the landfill was in operation when the subdivision was developed in the late 1970s, residents looked forward to the day it would close. As new residents moved in, many were told that the landfill was expected to have only a few years of remaining life, which was an accurate statement at the time because of the operational constraints described earlier.

Constructed Wetlands--The Key to the Future at Hillsboro Landfill

To replace the existing dike and close the existing landfill, it would be necessary to fill 13.5 acres of seasonal wetlands. In 1988, a Section 404 permit was applied for through the U.S. Army Corps of Engineers (Corps); it called for the creation of 13.5 acres of new wetlands in exchange for the area filled. While that application was under review, the concept of a phased landfill expansion, using a much larger constructed wetlands system, came under discussion between CH2M HILL and the landfill owner. The concept of extending the life of the facility was encouraged by officials at Metro and the DEQ at this point also.

The need for dike construction and cover material at the landfill required either borrowing soil from lowland areas in the flood plain, or importing fill. Using soil from a borrow source on landfill property would have an obvious economic benefit, but would require alterations to the flood plain and its sensitive wetland areas. Any such work would require modification of the Corps Section 404 permit, with the concurrence of several other agencies. Although this permitting process appeared to be a major obstacle to implementation of the expanded landfill concept, a properly designed and operated constructed wetland system at the site was seen as an opportunity to achieve several objectives, including:

- Creation of high-quality year-round habitat for diverse wildlife populations
- Treatment of storm drainage water from the landfill and surrounding areas
- Retention of spring runoff water to augment Tualatin River flows during the late summer
- Provision of a means of groundwater recharge
- Creation of an attractive open space for enjoyment by adjacent residents and visitors
- Development of an example of wetlands preservation that can serve as a model for others and that provides research and educational opportunities

As the conceptual plan for the wetlands came under discussion between specialists in these areas and the landfill owner, the means to meet various agency goals also became apparent. An integrated wetlands system could achieve the above objectives, which correspond quite closely with the goals of several agencies and other groups.

The concept of an expanded wetlands system was therefore developed. The concept included using borrow locations as wetlands and as a storage reservoir that could be used to provide a flow of water through the system during the summer months. A conceptual plan was submitted to the Corps shortly after issuance of the initial 404 permit. This plan would require modification of the initial permit to incorporate an integrated system over a much larger area.

The plan was then presented and discussed in meetings with representatives of several groups and agencies, including:

- U.S. Army Corps of Engineers
- Division of State Lands
- Oregon Department of Fish and Wildlife
- Oregon DEQ
- Unified Sewerage Agency
- City of Hillsboro
- Jackson Bottom Steering Committee

- Friends of Jackson Bottom
- Portland Audubon Society
- Local residents

This open exchange between agencies and other groups played an essential role in the success of the project. The landfill owner, Mr. Gary Clapshaw, made a special effort to meet with each resident bordering the site to describe the long-range plan. Residents' enthusiasm for the plan was nearly universal, particularly among those who would have a view of the pond areas from their back doors.

During this period, the Jackson Bottom Concept Master Plan was under development, funded by the City, Unified Sewerage Agency, and Washington County Soil Conservation District. The plan, adopted in 1989, listed resource management goals and suggested land uses over this sensitive area that would serve to meet area wildlife, recreation, and water management needs in an integrated manner.

The activities under consideration at the landfill were the first opportunity to implement the goals of the new Concept Master Plan. Therefore, close communication was established with the Jackson Bottom Steering Committee, and its input was sought in development of the design and operational features of the wetland system.

The plan was presented to the Corps in interagency meetings and was approved, subject to certain design changes, more detailed water management plans, revegetation plans, and monitoring and maintenance plans.

The following section summarizes the design and function of the wetlands system now in place.

Wetland System Description

Water Management and Treatment

The water system that maintains wetland function is a flow-through system. The primary source of water into the system is from upstream storm drainage and groundwater seepage, along with some surface flow from the landfill. The drainage area includes roads, residential areas, and greenhouses used for propagation of ornamental plants. Runoff from the greenhouses typically contains high levels of nutrients.

Water enters the storage reservoir via a 24-inch culvert (see Figure 1). The initial section is a 3.5-acre-foot-capacity treatment cell. Detention time in this section provides significant removal of sediment containing most of the contaminants found in stormwater, including metals, organics, and phosphorus compounds.

The storage reservoir has a total capacity of 100 acre feet. The reservoir outlet structure is gated to allow controlled release of water during the dry months. The water balance of the system has been developed to eliminate stagnation, yet foster plant growth and habitat creation. Flow through the system is controlled through very simple hydraulic structures that need no operation other than opening the reservoir outlet in the dry season and closing it again in the fall.

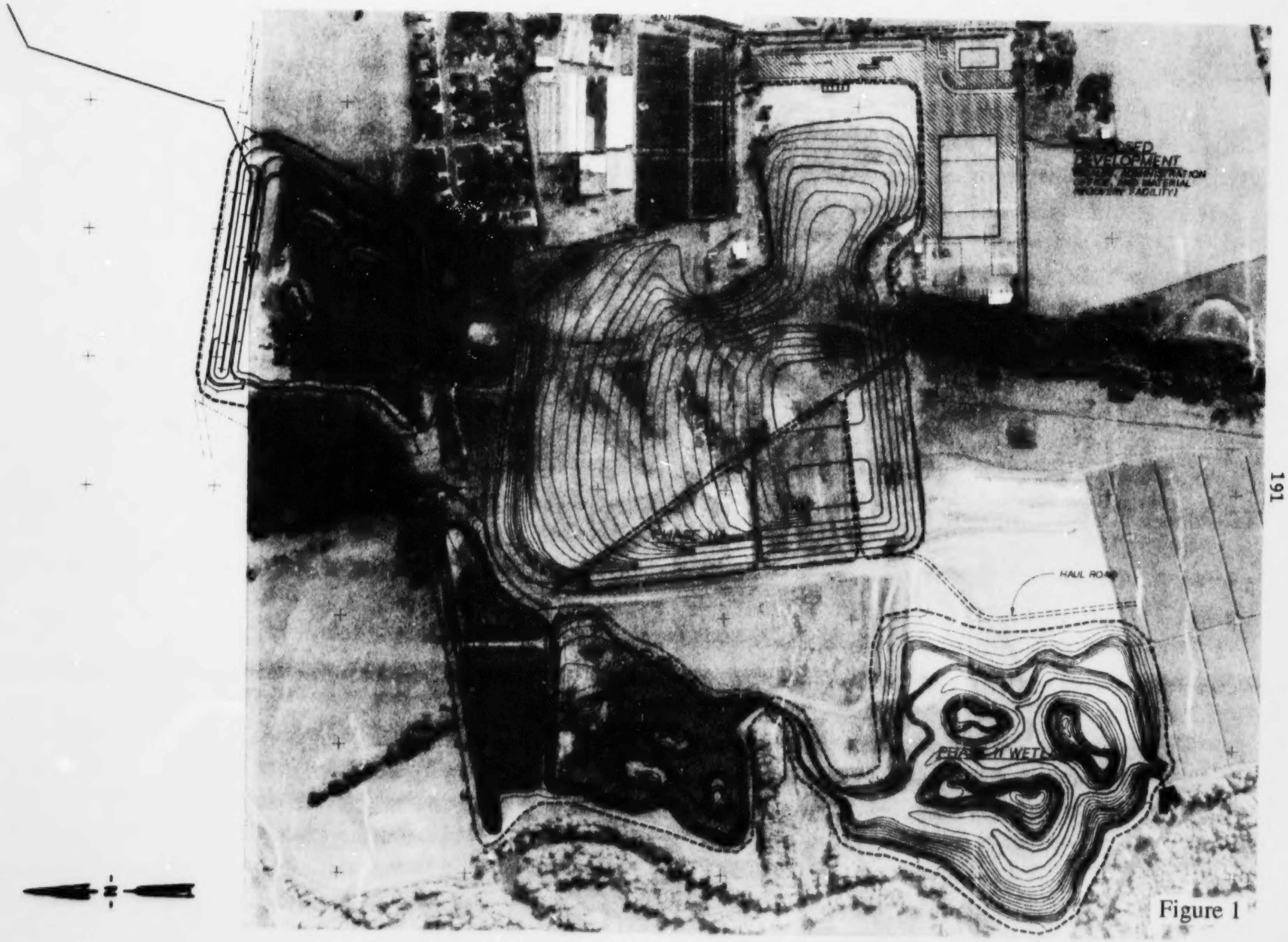
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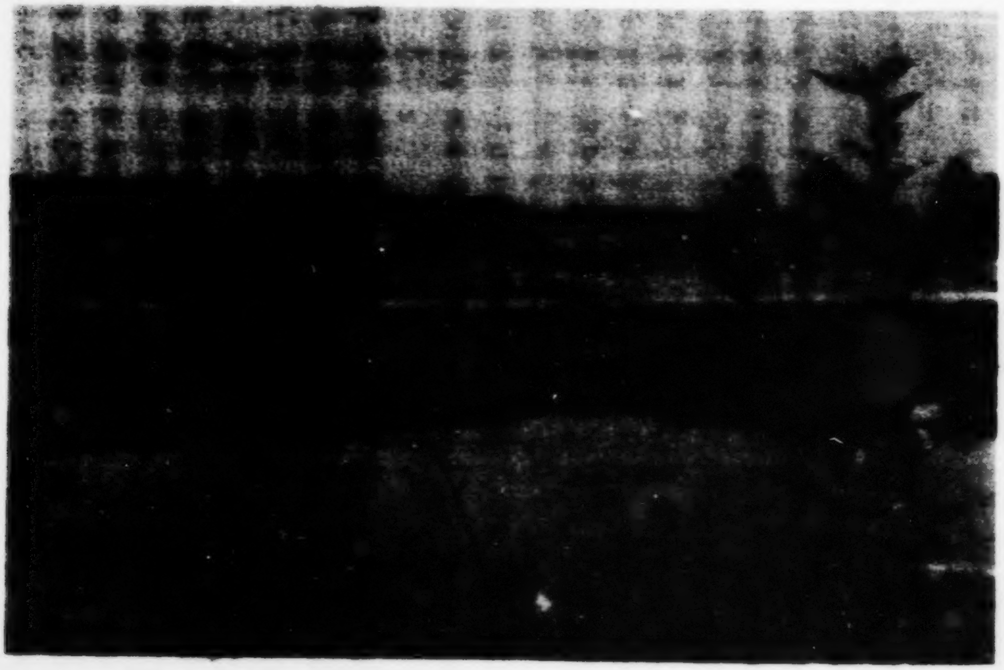
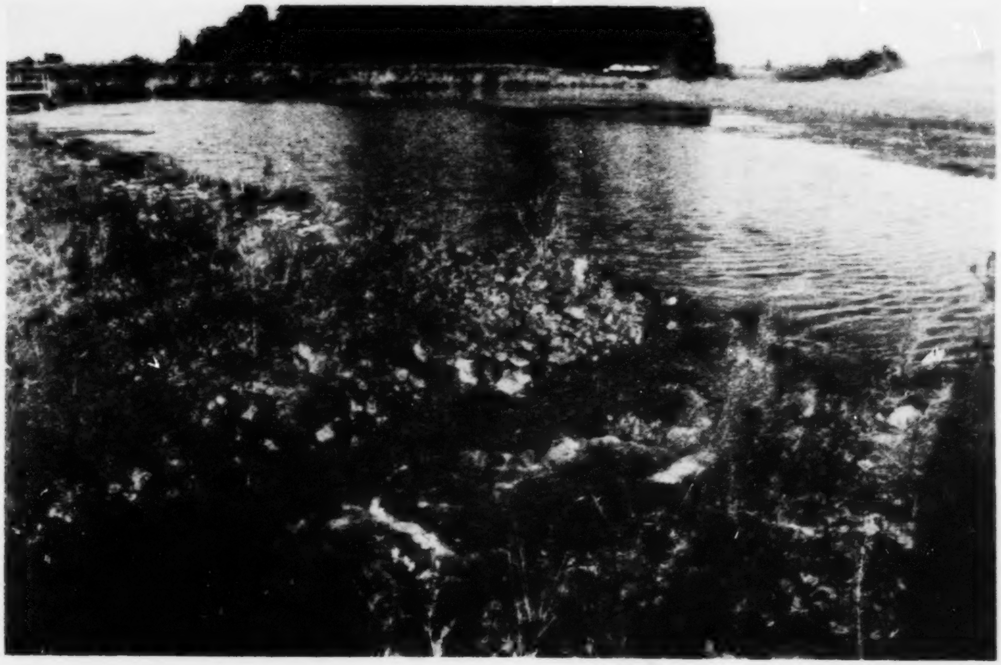
Figure 1

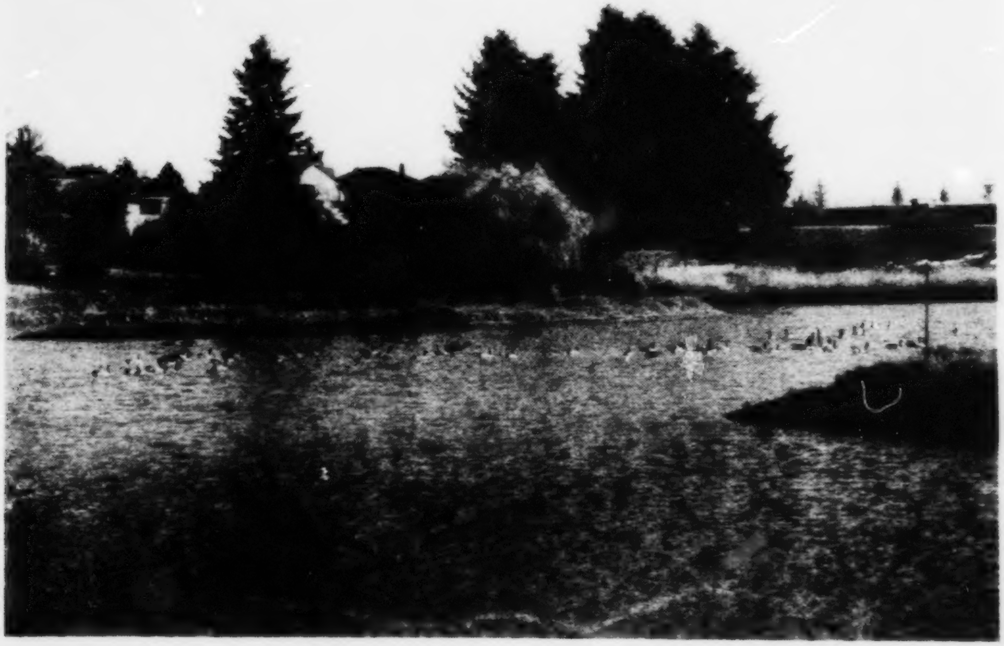
Aerial view of Hillsboro Landfill in July 1990. Wetlands are at center left.



Phase 1 wetlands, Cell III. Landfill containment dike in background.



Outlet spillway, wetlands Phase 1, Cell II.



Homes adjacent to storage pond.

The initial wetland cell is only 1 to 2 feet deep, so there is maximum soil contact. This facilitates settling of additional sediments and their associated contaminants. Cells II and III are deeper and support permanent emergent wetland vegetation. This vegetation provides sites for microbial breakdown of nitrogenous compounds and removes nutrients through plant uptake.

The present outlet of the system is through a channel to the Tualatin River. When Phase II of the wetlands is constructed in 1992, Phase I will be connected to it before discharge to the river. Subsequent wetland phases, to compensate for further landfill expansion, will be located farther south.

Revegetation Plan

The borrow areas to be used as wetlands were excavated to conform with the cell design described above. The excavation left a total of seven islands, which function as protected wildlife resting and nesting areas. The revegetation plan was based on the development of four distinct wildlife and wetland zones: open water, emergent wetlands, seasonal wetlands, and a riparian buffer of trees and shrubs. Selection of plants and seed mixtures was based on criteria provided by the resource agencies.

Landfill Master Plan

The approved master plan for the landfill consists of a series of independent modular units (phases) that extend the disposal area south of the current active landfill area (see Figure 1). Each phase of the long-term expansion program will provide approximately 5 years of disposal capacity and will accommodate closure of the entire facility if necessary for any reason.

Recent closure activity and development of new active landfill areas are described in the following sections.

Containment Dike

The original dike has now been replaced with a new dike located in an area with better foundation conditions and designed to provide adequate protection from the effects of a 100-year flood. The location and design of the new dike are based on the results of geotechnical explorations. Figure 2 is a plan view of the dike, drainage and leachate control system, and landfill cells.

Development of Phase II Landfill Area

Soil conditions require that the entire Phase II area be preloaded to induce settlement before construction of the bottom liner and leachate collection system. The amount of preload was determined based on the total projected weight of waste in Phase II.

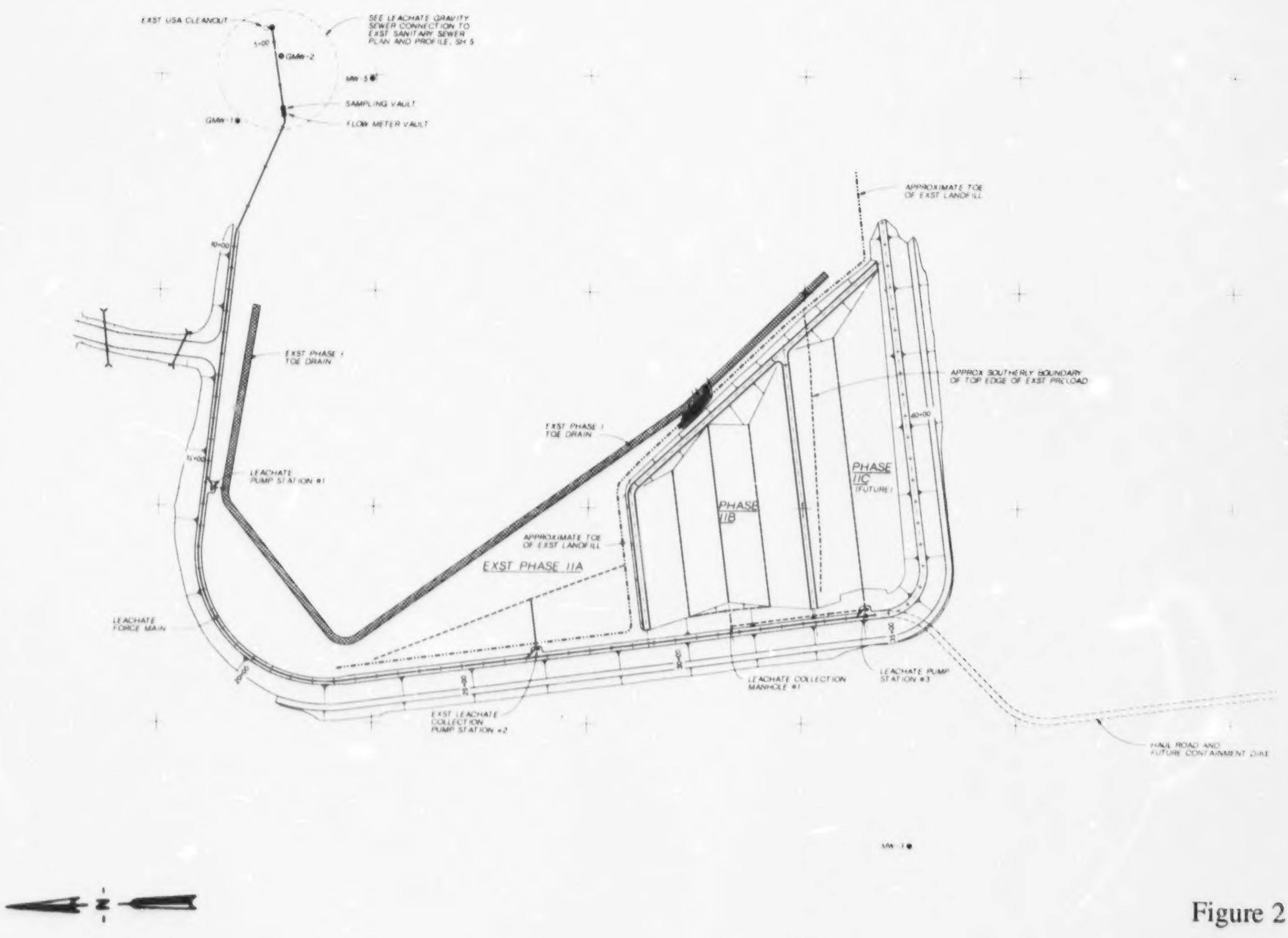

EXST USA CLEANOUT
SEE LEACHATE GRAVITY SEWER CONNECTION TO EXST SANITARY SEWER PLAN AND PROFILE, SH 5
5+00
GMW-2
MW-5
SAMPLING VAULT
GMW-1
FLOW METER VAULT
APPROXIMATE TOE OF EXST LANDFILL
10+00
EXST PHASE I TOE DRAIN
APPROX SOUTHERLY BOUNDARY OF TOP EDGE OF EXST PRELOAD
40+00
EXST PHASE I TOE DRAIN
15+00
LEACHATE PUMP STATION #1
PHASE IIC (FUTURE)
PHASE IIB
APPROXIMATE TOE OF EXST LANDFILL
EXST PHASE IIA
LEACHATE FORCE MAIN
35+00
30+00
20+00
25+00
LEACHATE COLLECTION MANHOLE #1
LEACHATE PUMP STATION #3
EXST LEACHATE COLLECTION PUMP STATION #2
HAUL ROAD AND FUTURE CONTAINMENT DIKE
MW-3
N

Figure 2

Cell IIA is currently being used for waste disposal. During the 1990 construction season, onsite materials were used to fill the Cell IIB and IIC areas to an elevation approximately 10 feet above normal groundwater. Low-permeability onsite materials with hydraulic conductivity of 1.0 x 10^{-6} centimeters per second or less were then selectively excavated, placed, and compacted in lifts.

The preload material was then deposited to a predetermined level to induce proper settlement of the site. After removal of the preload, the flexible membrane liner was installed in September 1991. Future cells will be developed similarly, as the sequence continues to the south.

The leachate collection system from the earlier unlined Phase I area consists of a toe drain connected to a force main. Leachate collection from Phase II cells uses a buried collection pipe network connected to the common force main to the city sewer.

Final Closure and End Use

Closed portions of the landfill ultimately will be used as a park owned and operated by the City of Hillsboro. Design issues are currently under development between Hillsboro Landfill, Inc., and the City Parks and Recreation Department. It is anticipated that upper areas will be used for more active recreational purposes, while areas adjacent to the water storage pond and wetlands will be used for more passive purposes. Interpretive exhibits and trails are possible components of the lower park area, but must be carefully designed to preserve the integrity of constructed wetland habitat. It is therefore likely that parts of the area will be subject to restricted access.

Material Recovery Facility

The landfill master plan recently approved by the Oregon DEQ and the County calls for a reorientation of the existing access, shop buildings, and entrance station, and development of a material recovery facility. Movement of structures to the south reduces noise impacts for the adjoining subdivision and increases efficiency of the operation. The material recovery facility will process loads of high-grade demolition and other wastes to minimize wastes going to the landfill. These additions to the landfill operation were permitted easily, with no apparent opposition from residents.

Conclusions

The success of the project is closely tied to the creative partnership that formed between the owner and consultants, and their willingness to develop a project that would meet needs well beyond those necessary to operate a landfill.

Resource agencies, often perceived simply as impediments to project development, are often responding to overriding mandates to implement adopted management policies. In the case of this project, the owner was able to implement several such policies, which had a powerful effect in helping him meet his own long-term goals.

Accelerated Landfill Biostabilization

(La biostabilisation accélérée
des sites d'enfouissement)

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Landfill Technologies Inc.
West Sand Lake, New York

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

DIFFERENTIATION OF ADJACENT UNLINED AND LINED SOLID WASTE DISPOSAL FACILITIES FOR DETECTION MONITORING PROGRAMS

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INTRODUCTION

New landfills built to the state-of-art design criteria are commonly being constructed adjacent to traditional disposal areas which many not have liners and leachate collection systems. Even with extensive double composite liners the new facilities must demonstrate the engineering performance of the new cells through ground-water detection monitoring programs.

Selection of the proper locations for detection monitoring wells should be based on a holistic approach to the evaluation of a specific site. The placement of the ground-water wells in this process must weigh and balance data collected in the field, laboratory, and office.

The question "How much detection monitoring is enough?", when answered in the context of the number of monitoring wells required at a site, will be entirely site-specific. In general, the monitoring system designer should ensure that convincing evidence is established for each assumption, and for demonstrating the basic capability of the system to produce ground-water samples representative of both upgradient (background) and downgradient conditions. General rules of thumb are provided in this paper, but the reader should bear in mind that "enough" is a subjective determination, both for the questions of "how much" monitoring is necessary to provide a monitoring system capable of detecting ground-water-contamination, and "how much" demonstration is required to convince a regulatory agency of that capability.

The key word in most regulatory programs that require ground-water monitoring is "capable". The owner or operator of a facility required to monitor ground-water must install and implement a monitoring system capable of determining the facility's impact on ground water; it must be capable of yielding representative ground-water samples for analyses. The number, locations, and depths of the detection monitoring wells must be such that the system is "capable" of the "prompt" detection of any statistically significant differences in indicator parameters.

The monitoring system designer must base decisions on sufficient numbers and locations of monitoring wells on performance-oriented criteria to describe a sufficient monitoring system since it will be a very unusual monitoring situation in which as few as several downgradient wells would insure system capability. Some very simple geologic environments can be effectively monitored with the USEPA RCRA Subtitle C-specified minimum system of one upgradient and three downgradient wells, however, this level of monitoring may be representative of very few sites. It is not uncommon for monitoring systems to employ many sampling points in detection monitoring. This is especially true for sites located in heavily regulated states. This is also true for facilities in operation over long periods of time and consisting of multiple cells or expansions. Multiple cell or expansions, some of which may be unlined and without leachate collection systems, also serve to make detection monitoring of solid waste facilities a difficult process. In these cases, separate monitoring of closed cells or entire sites from adjacent modern facilities can add additional complexities to what would already be an involved procedure. This paper discusses the technical tools for defining a detection monitoring program where adjacent facilities may be impacting ground-water and thus, confusing the results of the ground-water sampling program.

REGULATORY CONCEPTS IN FACILITY MONITORING

Ground-water monitoring and corrective action regulations being proposed for Subtitle D are very similar to those being used in RCRA Subtitle C, the hazardous waste regulations. These requirements apply to all new and existing landfill units unless it can be demonstrated that there is no potential for the migration of contaminants from hte unit to the upper most aquifer during the active life of the landfill including the post-closure care period. Additionally, the states will be allowed to specify a phase-in period for these requirements at existing facilities and this period may be as long as five years.

Many of the regulatory concepts surrounding monitoring of all types of facilities evolve around compliance with U.S. EPA regulations on ground-water monitoring, specifically RCRA regulations (40CFR 264.97) for ground-water monitoring at hazardous waste and solid waste sites. For example, the owner or operator of a hazardous waste management facility must comply with the following requirements for any ground-water monitoring program developed to satisfy §264.98, §264.99, or §264.100 or §258.51:

(a) The ground-water monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer that:

(1) Represent the quality of background (upgradient) ground-water that has not been affected by possible leakage from a facility; and

(2) Represent the quality of ground water downgradient of the facility.

(b) If a facility contains more than one regulated unit, separate ground-water monitoring systems are not required for each regulated unit provided that provisions for sampling the ground water in the uppermost aquifer will enable detection and measurement at the compliance point of hazardous constituents (for Subtitle C sites) from the regulated units that have entered the ground water in the uppermost aquifer.

Drafts of Subtitle D requires that ground-water monitoring system will be required at all solid waste landfills to detect the presence of leakage from the site. The number, spacing, depth and construction of wells will be based on site-specific technical information. The system design must include a thorough characterization of aquifer thickness, ground-water flow rates and directions, and the saturated and unsaturated geologic units overlying the uppermost aquifer including thickness, sequencing, hydraulic conductivities, and porosities. However, the system must be installed at the compliance boundary used for design.

Many millions of dollars and millions of words in reports and meetings have been spent on defining exactly what these relatively few lines of text really mean in the context of actual monitoring of hazardous waste sites. Both RCRA Subtitle C (hazardous waste) and Subtitle D (solid municipal waste) facilities are required to meet these basic points of detection monitoring programs.

This Federal rule can be depicted in a single figure that illustrates the concept of detection monitoring. Figure 1 shows a conceptual presentation of the §264.97 guidance on placement of detection monitoring wells.

REGULATORY CONCEPT OF DETECTION MONITORING

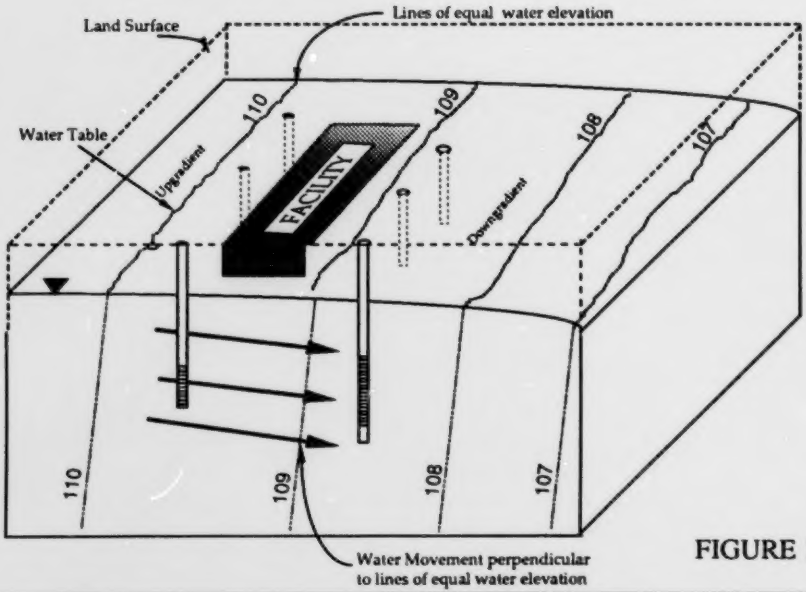

Lines of equal water elevation
Land Surface
Water Table
Upgradient
110
109
108
107
FACILITY
Downgradient
110
109
108
107
Water Movement perpendicular to lines of equal water elevation

FIGURE 1

The RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD), (U.S. EPA,1986) provided additional guidance on placement and number of upgradient or background wells by recommending that these wells be:

- Located beyond the upgradient extent of possible contamination from the hazardous waste management unit so that they reflect background water quality;
- Screened at the same stratigraphic horizon(s) as downgradient wells to ensure comparability of data.
- Of sufficient number to account for heterogeneity in background ground-water quality.

The conceptual homogeneous unconfined uppermost aquifer as illustrated in Figure 1 would meet the above three TEGD requirements; however, this conceptual hydrogeologic condition is seldom observed in the field in such a simple unconfined aquifer form. As site geologic condition get more complex, more comprehensive site investigations are needed for placement of the detection monitoring wells.

Many solid waste disposal facilities are located adjacent to unlined old sites in which even more complex site assessment investigations are required to properly locate the wells for detection ground-water monitoring systems so that impacts from existing facilities do not confuse the monitoring programs for the new lined sites.

An adequate detection monitoring program can be designed for any geologic/hydrogeologic environment using the above criteria and the concepts described in a new ASTM Standard D-5092 "Design and Installation of Ground Water Monitoring Wells in Aquifers". The one major complicating factor of separating potential discharges from the new facility from existing discharges from adjacent old unlined sites is addressed by following a technical sequence of investigation and analysis as presented below. The following sections also present conceptual hydrogeologic models for detection monitoring programs that provide guidance for monitoring system design for a variety of hydrogeologic and geochemical environments.

Prior to selecting the locations and depths for screened intervals for ground-water monitoring wells, the ground-water monitoring system designer must have, at a minimum, accomplished:

- Performed complete site characterization;
- Established a conceptual hydrogeologic model for the site;
- Constructed a ground-water flownet ; and
- Located facility boundaries and waste disposal areas.

Each of these tasks provide data that will be used to select the target monitoring zones for the monitoring system. The remaining sections describe the monitoring system process summarized in, Figure 2. Examples of the process are included to assist in the design conceptualization process.

DATA ANALYSIS REQUIRED FOR DESIGN

Geologic factors (related chiefly to geologic formations and their water-bearing properties) and hydrologic factors (related to the movement of water in the formations) must be known in some detail to properly design a ground-water monitoring system. These data are normally developed in a field investigation as described in ASTM D-5092-90.

The geologic framework of a site includes the lithology, texture, structure, mineralogy, and distribution of the unconsolidated and consolidated subsurface materials through which ground-water flows. The hydraulic properties of these earth materials depend upon the geologic framework. Thus, the geologic framework of the facility heavily influences the design of the ground-water monitoring system. Elements of the hydrogeologic framework and the site hydrogeology that should be considered in ground-water monitoring system design include:

- The spatial location and configuration of the uppermost aquifer and its hydraulic properties (e.g., horizontal and vertical hydraulic conductivities, depth and location of ground-water surface, seasonal fluctuations of ground-water surface elevation).
- Hydraulic gradient within the geologic materials underlying the facility.
- Facility and adjacent property operational considerations.

These data are used to establish the locations of both upgradient (back ground) and downgradient wells in the uppermost aquifer. Both upgradient and downgradient wells should be located in the direction of ground-water flow along flow pathways most likely to transport ground-water and contaminants contained in ground-water. These pathways should be identified using techniques as described in EPA (1986) guidance for construction of ground-water flow nets from data gained from existing information and preliminary site investigations. The objectives of the preliminary site investigation and subsequent data analysis and interpretation is to provide some or all of the following information:

- Lithologic characteristics, including:
  - established stratigraphic names
  - classification of hydrogeologic units
  - extent of hydrogeologic units
- Key hydrogeologic characteristics used to describe the site to the conceptual model including:
  - hydraulic conductivity
  - porosity
  - gradient
  - specific yield
- Aquifer characteristics including:
  - boundaries
  - type of aquifers
  - saturated/unsaturated conditions

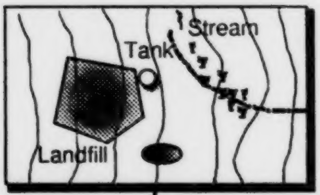
Each piece of data is an important building block in establishing the conceptual hydrogeologic model and targeting zones to be monitored. These data are used in combination to define the uppermost aquifer and hydraulic gradients to allow the identification of aquifer flow pathways so that target monitoring zones can be selected.

SELECT TARGET MONITORING ZONES

The first task in the design of a detection ground-water monitoring system is the selection of the target monitoring zone. The logic used in selection of the target monitoring zone is illustrated in Figure 2 (SARA 1991) a review of features of the facility to be monitored, used in combination with conceptual models and flownets provides the system designer with the information to select those zones that will provide a high level of certainty that releases from the facility will be "immediately" detected. The concept of the target monitoring zone was developed as a means of directing the ground-water monitoring system designer toward placement of well screens in the uppermost aquifer at locations and depths that would have the highest likelihood of detecting leakage from a facility. This target zone usually lies in the saturated geologic unit in which ground-water flow rates are the highest because it possesses the highest hydraulic conductivity of the material adjacent to or underlying the facility of interest. Figure 2 illustrates the process of selection of a target monitoring zone using information on facility features, geologic characteristics and hydraulic characteristics gathered during the preliminary field investigations. This selection process can be described as a series of steps:

- **Step 1: Locate Site Features on a Topographic Base Map Format:** site features should be compared to information on geologic and soils maps to define the location of important facility components in relation to the distribution of sufficial materials. Any likely recharge/discharge areas (streams, wetlands or other surface-water should be located. Adjacent facilities must be fully identified and used in later flow path analysis.
- **Step 2: Cross Section Construction and Conceptual Model Development:** cross-sections should be constructed, based on boring logs and/or geophysical traverses. These sections should be compared against the location of site features and facility components. The base grades of the facility should be plotted on cross-section relative to permeable geologic units or ground-water flow pathways. A conceptual model should be constructed to establish the site geological framework and to illustrate distribution of geologic materials of differing hydraulic conductivity.
- **Step 3: Use Flownet to Define Likely Direction Ground-Water Flow:** Construction of flownets will assist in defining the gradient and direction of ground-water flow in the uppermost aquifer. The rates of flow along flow paths can be calculated from the information provided by the flownet. Vertical gradients can be used to predict target zones by comparison of relative heads between units. Interconnections between aquifers can be predicted from relationships of relating hydraulic conductivity to hydraulic heads for the units defined in the conceptual models.
- **Step 4: Select Target Monitoring Zones:** The zone meeting the regulatory definition of the uppermost aquifer, which also shows primarily horizontal ground-water movement under or adjacent to the facility would therefore represent the target monitoring zone. This zone would probably represent a permeable unit that is dis-

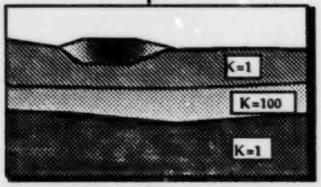
SELECT TARGET MONITORING ZONES



BASE MAP

LOCATION OF SITE FEATURES

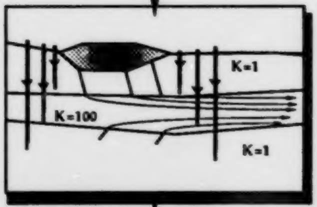
- *Topographic map format*
- *Plot all pertinant site features on map*
- *Suficial geology and soils should be available for analysis*
- *Define recharge and discharge areas on map*



CONCEPTUAL MODEL

CONCEPTUAL MODELS & CROSS SECTIONS

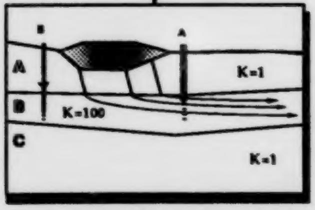
- *Prepare cross section with lithology*
- *Define facility base grades*
- *Compare base grades with permeable units*
- *Establish most likely uppermost aquifer*



FLOW NET

GROUND WATER FLOW DIRECTIONS

- *Plot water table & piezometric heads*
- *Define relative heads between units*
- *Check for interconnection between aquifers*
- *Calculate rates of ground-water movement*
- *Plot flow directions using flow lines & equipotentials*
- *Establish if vertical gradients would predict target zone*



TARGET MONITORING ZONE

SELECT TARGET MONITORING ZONES

Vertical heads in unit A

Horizontal flow in unit B

Unit C confining (aquitard) with upward gradient

Figure 2

charging to other permeable units or to local discharge areas. The system designer should be aware of the flow

paths within the uppermost aquifer that would represent the most likely zones of ground-water movement away from the facility. These zones, typically those with the highest hydraulic conductivity would be the focus of the detection monitoring system. If interconnected aquifers are present, these units should be monitored as necessary to provide safeguards of downgradient ground water users.

This four-step procedure for selecting the target monitoring zone must be flexible enough to accommodate environmental effects due to seasonal changes in gradient or due to the plan to expand or alter the configuration of the facility. The target zone might include only a portion of a very thick aquifer (for example, the top 30 feet), or span several geologic units (as in the case of a thin, permeable, unconsolidated unit overlying weathered and/or fractured bedrock). These target zones represent the proper location for placement of monitoring wells.

The target monitoring zones are further useful for the separation of detection ground-water monitoring systems from adjacent facilities that may have been unlined or are currently impacting water quality. The following three case histories illustrate how ground-water flow concepts can be effectively used to evaluate the optimum locations and depths of a detection monitoring system.

SIMPLE GRADIENT CONTROL

Facility `A' represents a relatively simple condition where the existing twenty (20) acre landfill is located in a downgradient position from a twenty five (25) acre expansion as shown on Figure 3a. The expansion has both a 60 mil HDPE liner and leachate collection. Ground-Water table contours, shown on Figure 3a, when combined with the hydrogeological cross-section (Figure 3b) shows the target monitoring zone to be the Pleistocene Terrace deposits of interlayered sand and clayey sands. The underlying Choctawhatchee formation was not judged to be significantly more permeable than the Terrace deposits and both formations are underlain by the locally non-water bearing Hawthorn formation. As such, ground-water would not have a significantly downward movement adjacent to the site and detection monitoring wells should be located between the two facilities. The flatness of the ground-water contours as they pass under the site show that there is not significant mounding in the existing facility. This facility would not cause the area between the two facilities to be discharge point for the existing site. Wells located between the facilities with the observed ground-water flow conditions would monitor the expansion. At least two upgradient wells between the 65' and 70' ground water contour line would be necessary to provide background water quality samples. The well depths should be completed between the base grade of the expansion and the base of the Terrace deposits.

GRADIENT AND LITHOLOGY CONTROL

Site `B' represents a slightly more complex example where a ground-water divide and lithology complicates ground-water monitoring conditions. Figure 4a shows a 16 acre lined cell with leachate collection adjacent to a five (5) acre closed commercial, and large closed County landfill. The hydrogeologic cross-section, Figure 4b illustrates the lithology and base grade configurations for the site. The site's geology/hydrogeology is dominated by the thick (100 ft.) Cooper formation which acts as a regional confining unit. The shallow aquifer Pleistocene sands and clays has a generally unsaturated upper sand unit with an intervening clay unit overlying a saturated lower sand unit.

The hydrogeologic cross-section, as presented, is insufficient to fully evaluate the localized flow conditions for selecting locations for detection monitoring wells. Cross-section G-G' (Figure 4c) must be evaluated in combination with water table contours shown on Figure 4a. The water table contours show a ground-water divide occurring along a natural ridge area. The new lined cell is located along the nose of the ridge and also on top of the ground-water divide. Monitoring of sites located on ground-water divides require almost a three sided approach to the detection monitoring program. If the cell was located directly on top of a hill, down gradient could be in all four directions and monitoring for background ground-water quality would be generally more complicated. Background water quality for the example `B' site would, however, be along the ridge line in the locations shown between MW-7 and MW-6. Downgradient locations would be located from MW-1A clock wise around through MW-5. Since the site has sufficient ground-water gradients from the new cell toward the old closed county and commercial sites, local discharge between the old and new sites would not be considered a problem. The cross-section of G-G' illustrates a combined conceptual model of the site geology and the observed ground-water flow paths. Flow path A represents a

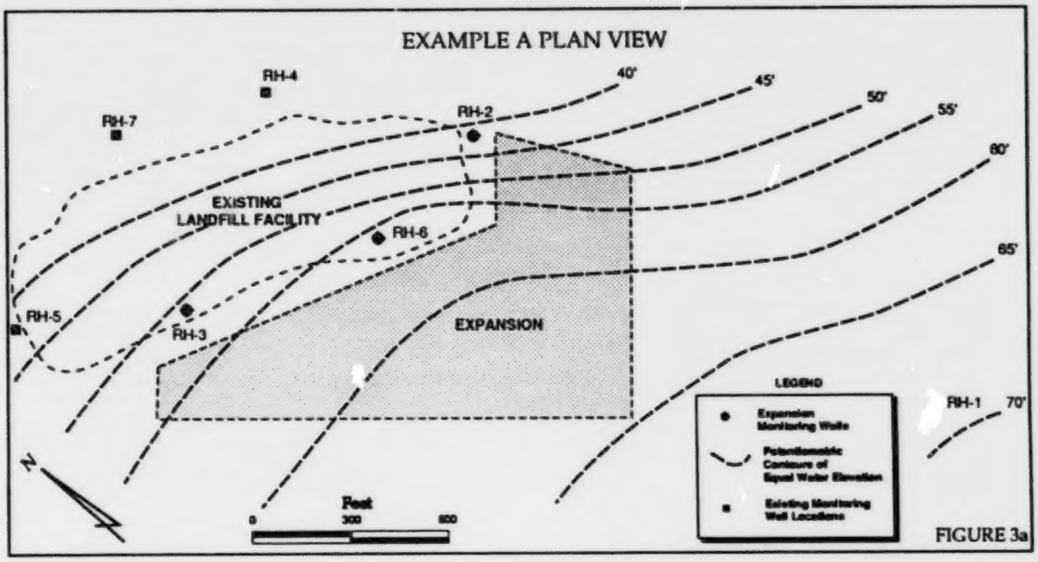
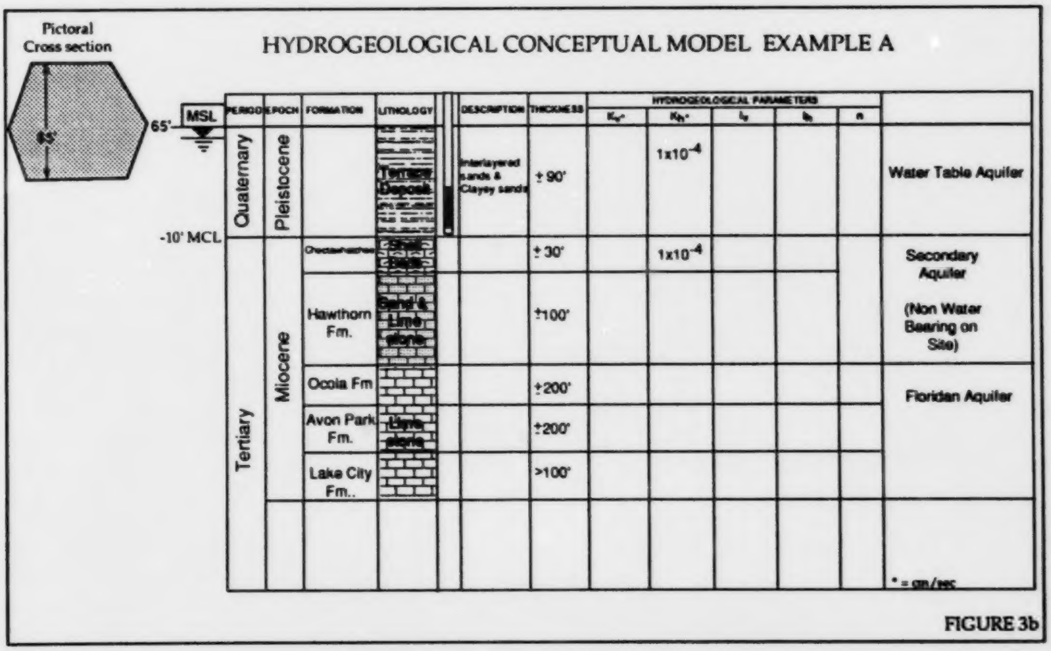

EXAMPLE A PLAN VIEW
RH-4
RH-7
RH-2
40'
45'
50'
55'
60'
65'
70'
EXISTING
LANDFILL FACILITY
RH-6
RH-5
RH-3
EXPANSION
RH-1
N
Feet
0
300
600
LEGEND
Expansion Monitoring Wells
Potentiometric Contours of Equal Water Elevation
Existing Monitoring Well Locations

FIGURE 3a

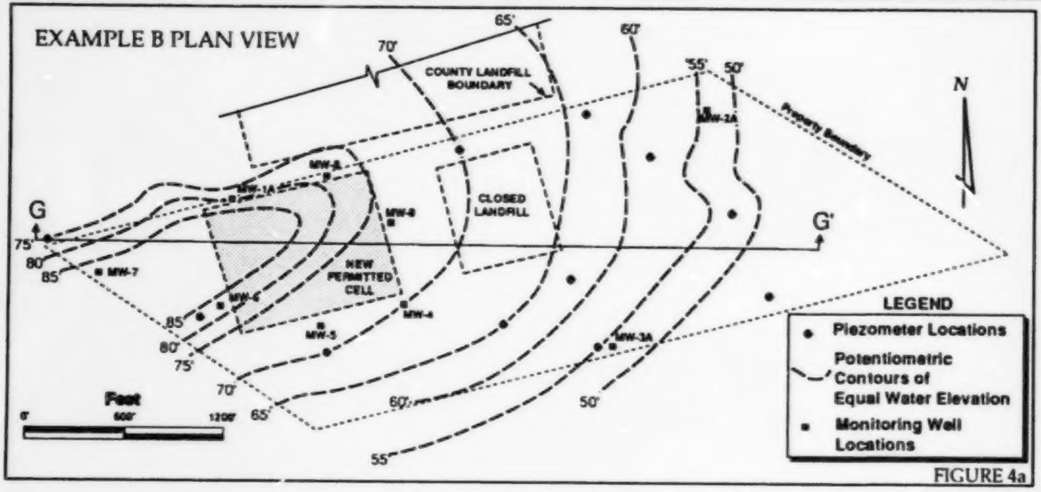

Pictoral
Cross section
65'
65'
MSL
-10' MCL

HYDROGEOLOGICAL CONCEPTUAL MODEL EXAMPLE A

PERIOD	EPOCH	FORMATION	LITHOLOGY		DESCRIPTION	THICKNESS	HYDROGEOLOGICAL PARAMETERS					
							K_v*	K_h*	i_v	i_h	n	
Quaternary	Pleistocene		Terrace Deposit		Interlayered sands & Clayey sands	± 90'		$1x10^{-4}$				Water Table Aquifer
Tertiary	Miocene	Choctawhatchee	Shell beds			± 30'		$1x10^{-4}$				Secondary Aquifer (Non Water Bearing on Site)
		Hawthorn Fm.	Sand & Lime stone			±100'						
		Ocola Fm				±200'						Floridan Aquifer
		Avon Park Fm.	Lime stone			±200'						
		Lake City Fm..				>100'						

* = cm/sec

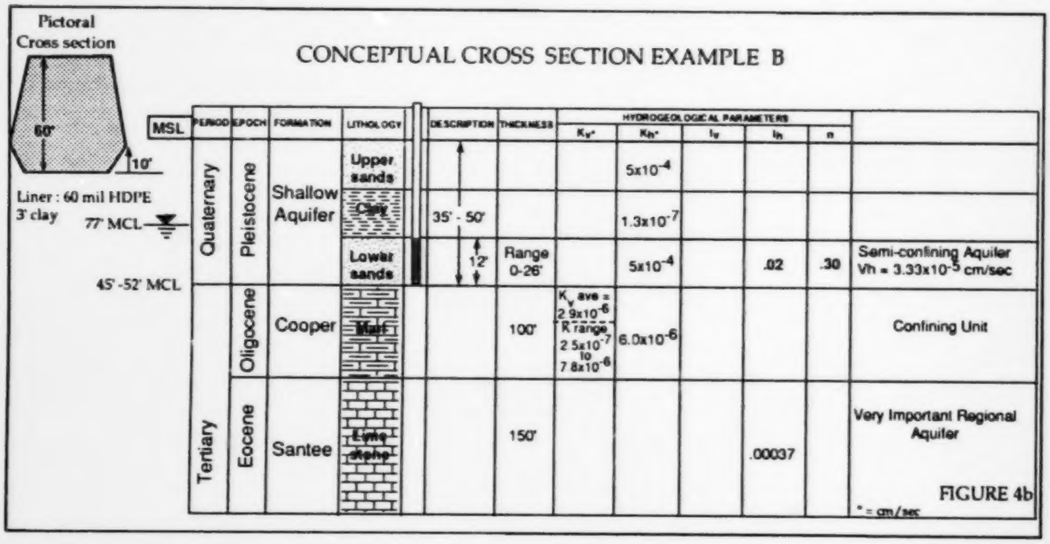
FIGURE 3b



EXAMPLE B PLAN VIEW

COUNTY LANDFILL BOUNDARY
CLOSED LANDFILL
NEW PERMITTED CELL
Property Boundary
MW-1A
MW-8
MW-6
MW-7
MW-C
MW-4
MW-5
MW-2A
MW-3A
G
G'
N
85'
80'
75'
70'
65'
60'
55'
50'
Feet
0'
600'
1200'
LEGEND
Piezometer Locations
Potentiometric Contours of Equal Water Elevation
Monitoring Well Locations

FIGURE 4a



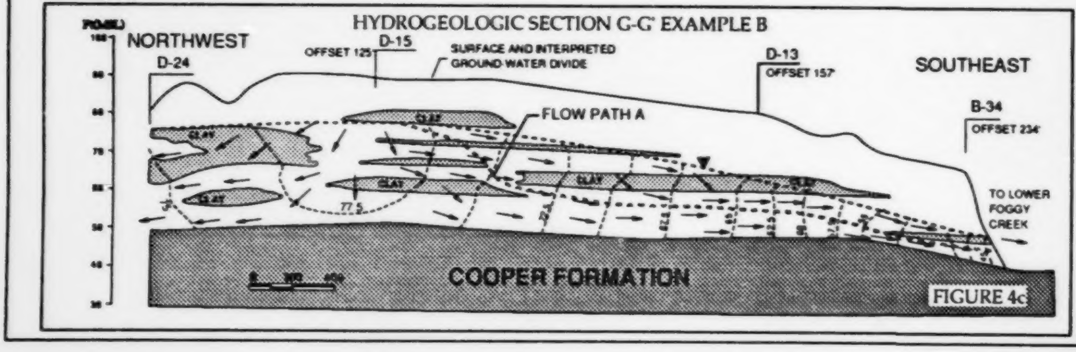
CONCEPTUAL CROSS SECTION EXAMPLE B

Pictoral Cross section
60'
10'
Liner : 60 mil HDPE
3' clay
77' MCL
45'-52' MCL
MSL

PERIOD	EPOCH	FORMATION	LITHOLOGY	DESCRIPTION	THICKNESS	HYDROGEOLOGICAL PARAMETERS					
						K_v*	K_h*	I_v	I_h	n	
Quaternary	Pleistocene	Shallow Aquifer	Upper sands				5×10^{-4}				
			Clay	35' - 50'			1.3×10^{-7}				
			Lower sands	12'	Range 0-26'		5×10^{-4}		.02	.30	Semi-confining Aquifer Vh = 3.33×10^{-5} cm/sec
Tertiary	Oligocene	Cooper	Marl		100'	K_v ave = 2.9×10^{-6} K range 2.5×10^{-7} to 7.8×10^{-6}	6.0×10^{-6}				Confining Unit
	Eocene	Santee	Limestone		150'				.00037		Very Important Regional Aquifer

FIGURE 4b

* = cm/sec



HYDROGEOLOGIC SECTION G-G' EXAMPLE B

FT(MSL)
100
90
80
70
60
50
40
30
NORTHWEST
SOUTHEAST
D-24
D-15
OFFSET 125'
SURFACE AND INTERPRETED GROUND WATER DIVIDE
D-13
OFFSET 157'
B-34
OFFSET 234'
FLOW PATH A
CLAY
77.5
TO LOWER FOGGY CREEK
COOPER FORMATION
0
300
600

FIGURE 4c

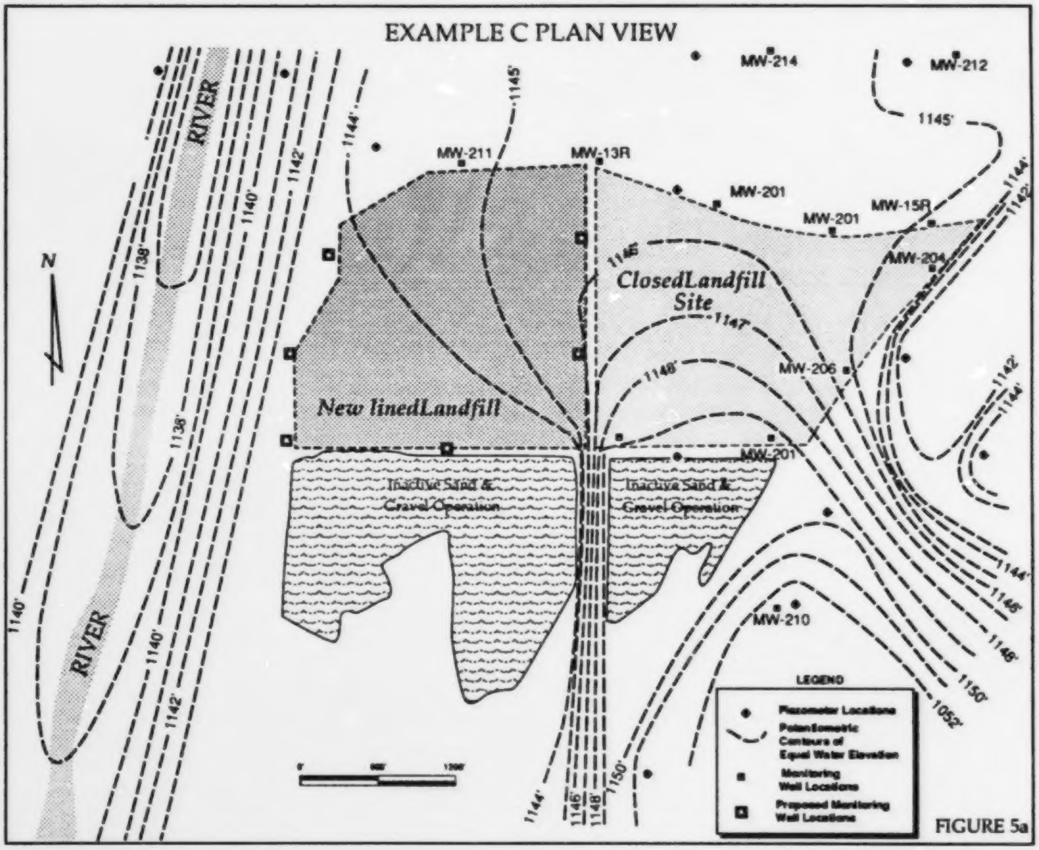

EXAMPLE C PLAN VIEW
MW-214
MW-212
1145'
MW-211
MW-13R
MW-201
MW-201
MW-15R
MW-204
MW-206
MW-201
MW-210
RIVER
RIVER
N
1138'
1140'
1142'
1144'
1145'
1146'
1147'
1148'
1150'
1052'
ClosedLandfill Site
New linedLandfill
Inactive Sand & Gravel Operation
Inactive Sand & Gravel Operation
0
600'
1200'
LEGEND
Piezometer Locations
Potentiometric Contours of Equal Water Elevation
Monitoring Well Locations
Proposed Monitoring Well Locations

FIGURE 5a

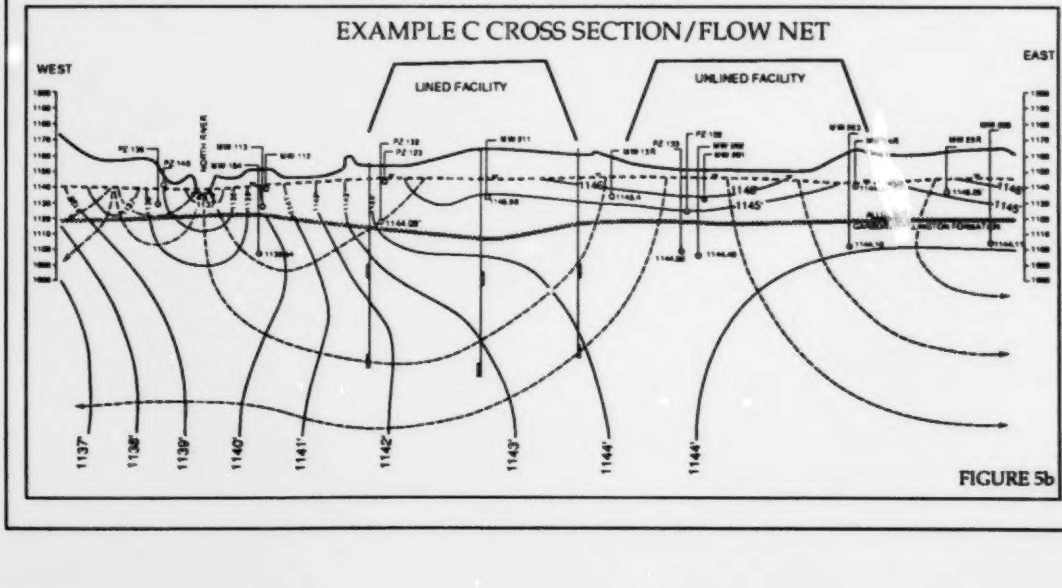
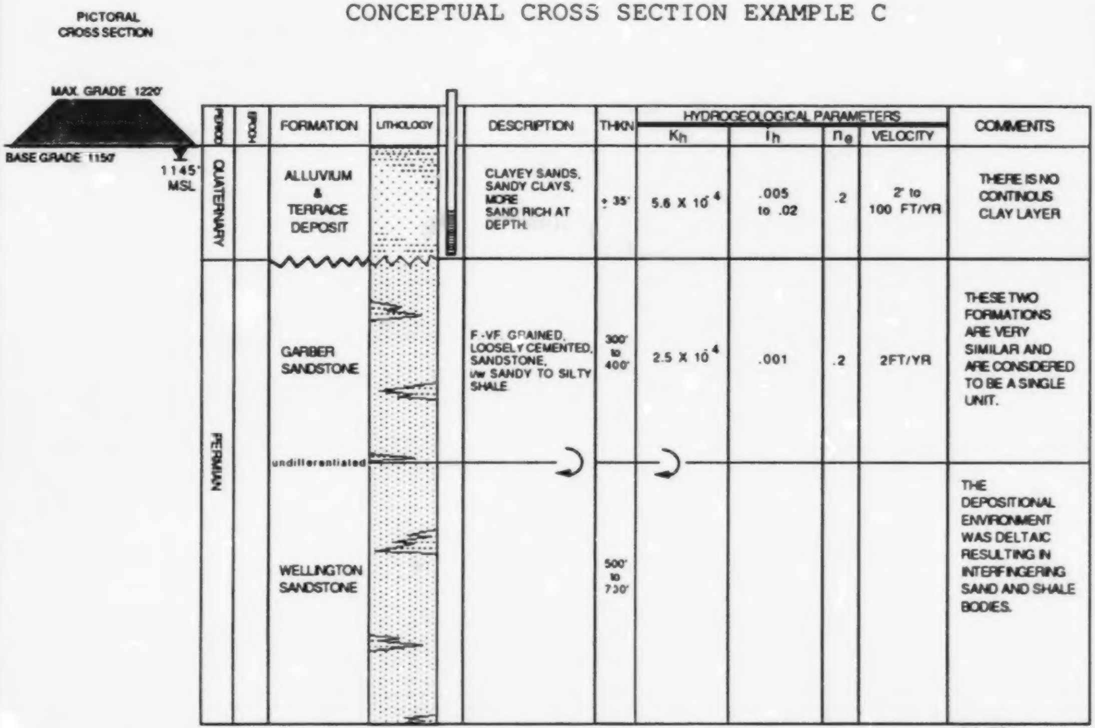

EXAMPLE C CROSS SECTION / FLOW NET
WEST
EAST
LINED FACILITY
UNLINED FACILITY
NORTH RIVER
MW-13R
1146'
1145'
1148'
1137'
1138'
1139'
1140'
1141'
1142'
1143'
1144'
1144'

FIGURE 5b

CONCEPTUAL CROSS SECTION EXAMPLE C


PICTORAL CROSS SECTION
MAX. GRADE 1220'
BASE GRADE 1150'
1145' MSL
undifferentiated

PERIOD	EPOCH	FORMATION	LITHOLOGY	DESCRIPTION	THKN	HYDROGEOLOGICAL PARAMETERS				COMMENTS
						K_h	i_h	n_e	VELOCITY	
QUATERNARY		ALLUVIUM & TERRACE DEPOSIT		CLAYEY SANDS, SANDY CLAYS, MORE SAND RICH AT DEPTH.	± 35'	5.6×10^{-4}	.005 to .02	.2	2' to 100 FT/YR	THERE IS NO CONTINOUS CLAY LAYER
PERMIAN		GARBER SANDSTONE		F.-VF. GRAINED, LOOSELY CEMENTED, SANDSTONE, i/w SANDY TO SILTY SHALE	300' to 400'	2.5×10^{-4}	.001	.2	2FT/YR	THESE TWO FORMATIONS ARE VERY SIMILAR AND ARE CONSIDERED TO BE A SINGLE UNIT.
		undifferentiated								
		WELLINGTON SANDSTONE			500' to 730'					THE DEPOSITIONAL ENVIRONMENT WAS DELTAIC RESULTING IN INTERFINGERING SAND AND SHALE BODIES.

FIGURE 6

potential flow line from below the lined facility in one direction toward a local creek discharge point. A flow path could also be drawn in the opposite direction (as represented by the ground-water divide shown in the Figure 3c).

The well screen depths that would most effectively cover the facility in a detection monitoring system should be located in the sandy unit above the Coopers Formation, directly below the first saturated Pleistocene clay unit. Downgradient detection monitoring wells should be located in both cross-section directions as indicated by the ground water flow arrows. Information on local lithology and ground-water flow nets make selection of potential depths for well screens a relatively straight forward task. The previous two examples represent primarily horizontal ground-water flow conditions; the following example `C, shown in Figure 5, however, represents a more complex three-dimensional example linkage of flow and lithology.

COMPLEX GROUND WATER FLOW CONDITIONS

Site `C' represents a new 70 acre lined site with leachate collection adjacent to a closed 80 acre MSW landfill (Figure 5a). The closed site is currently being investigated under the federal CERCLA program. The uppermost aquifer as shown in Figure 6 is the Pleistocene Alluvium (35 feet thick). The underlying Garber-Wellington Formation (300 to 400 ft. thick) is the main regional aquifer. The Garber-Wellington Formation shows hydraulic conductivities similar to the overlying alluvium, so simple horizontal flow conditions cannot be assured for detection monitoring purposes. The ground-water contour plan (Figure 5a) shows complex localized flow conditions exist at the site due to the effects of the inactive sand and gravel operations (now full of water), and the river to the west of the site. Ground-water movement is generally from the southeast to the west of the new facility. However, local discharges also occur to the east of the closed facility. The physical condition of having an unlined site generally upgradient of a new facility can make interpretation and comparison of background and downgradient water quality very difficult. The ground-water flow conditions are furthered complicated by having no confining units to separate the uppermost aquifer (alluvium) from deeper regional aquifers.

This site must be evaluated through use of a linked conceptual model and flownet construction cutting an East-West cross-section. Figure 5b illustrates site flow conditions through the uppermost aquifer into the Garbor-Wellington and discharging in two directions (West & East). The lined site's potential flow path discharges to the river and as such, can be monitored with wells completed between 1080' and 1130' above MSL.. This fifty foot zone represents the most likely flow path for potential discharges from the lined facility. Completion of deeper monitoring wells would intercept flow paths coming from the unlined facility and, as such, would not represent true downgradient conditions from the active disposal site.

Background wells must also be carefully chosen relative to adjacent facilities and the overall geology and ground-water flow conditions. The example `C' monitoring wells are located between the new facility and the river in an arc down to the sand and gravel operation south of the lined cell.

Background wells are located between the closed site and the new facility. As with the downgradient detection monitoring wells the background water-quality monitoring points must be carefully selected relative to depth of the well screens. They should probably be no deeper than being screened between elevation 1140'and 1130' feet above MSL. As with any detection ground-water monitoring system located adjacent to an unlined facility, the wells must be entirely screened below the seasonal low water table. This is to insure that landfill gas potentially moving in the vadose zone from the unlined site would not enter a monitoring well and cross-contaminate ground-water samples taken from the well. This type of cross-contamination can greatly confuse detection monitoring analytical results. Gas movement in the vadose zone should be monitored through a separate gas monitoring network designed especially for the purpose.

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Landfill Leachate Containment and Collection System Design, a Performance Criterion Approach

(La conception d'un système de
retenue et de collecte des lessivats
d'une décharge: une approche basée
sur des critères de rendement)

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Calgary, Alberta

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

LEACHATE GENERATION PATTERNS IN MSW LANDFILLS IN WISCONSIN AND HELP MODEL ASSESSMENT

BY
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Mack, D.P.[5], and Mitchell, G.R.[5].

Presented at the Waste Tech' 91, Canadian Solid Waste Management Conference
Toronto, Canada, October 30 - Nov. 1., 1991.

ABSTRACT

Leachate generation rates from 4 containment type Municipal Solid Waste (MSW) landfills in Wisconsin were investigated for the period 1980-89. Three of the sites used in this study were built with a 5 foot clay liner and a leachate collection system. The leachate data fluctuated from site to site, and showed high fluctuation profile during the site operating period. Low generation profile was observed after the site closure. The leachate generation prediction provided by the HELP model which was simulated with site specific soil and climatological data, were compared to field observations. Preclosure simulation conditions overpredicted the leachate generation, with an average error varying from + 84.1 to + 196.7% (Dane, Sauk and Metro-S40 data). In postclosure simulation, the model underpredicted the leachate generation rate, with an error of - 42.6%. The results of this study showed that leachate prediction using the HELP model can provide reasonable estimate if the site sequential simulation with area adjustment and waste field capacity initialization procedures are used.

INTRODUCTION

The need for predicting leachate generation at landfill has lead to the formulation of several models (Wong, 1977; Demetracopoulos et al., 1984; Korfiatis and Demetracopoulos, 1986; Schroeder et al., 1984; Bagchi and Ganguly, 1990). The estimates provided by the water balance method as developed by Fenn et al. (1975) yields an error varying from -83 to +1543% (SCS engineer 1976; Bagchi, 1990). Literature indicate that HELP model is capable of predicting leachate collection volume from MSW landfills with low to moderate accuracy (Peyton and Schroeder, 1988; Krantz and Bailey, 1990).

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This paper discusses the results of leachate generation rates from selected landfills in Wisconsin, and compares the field data to the HELP model predictions. The purpose is to assess the reliability of the model when applied to site specific data from Wisconsin.

METHODOLOGY

The study design included the following approach:

1) site selection.
2) HELP model simulations.
3) analysis of data.

Site Selection

The sites included in this review are Eau Claire County, Dane County, Sauk County and Metro-S40 landfills. All the sites were designed as containment landfills. Details regarding clay liner thickness and leachate collection system (LCS) are included in Table 1.

Eau Claire County landfill is a 24 acre site with a total capacity of $1.5E^6$ cy. The site was operated in 6 phases, from 1978 to '89. Sequential development as well as the area under different final contour slopes (side slope from 20% to 25%, top slope from 3% to 5%) were considered during the HELP simulations.

Dane County landfill encompasses 52 acres located about 5 miles east of Madison. The landfill opened in 1985 and has a total capacity of $3.8E^6$ cy. It's development includes 4 phases. The first phase closed in 1987 with a final contour (side slope) of 25%.

Sauk County landfill encompasses 20 acres with a capacity of $1.5E^6$ cy to be filled in 4 phases. The landfill has a collection basin (lysimeter) under the liner. The landfill was simulated as completely open from 1985 to '89.

Metro-S40 landfill was built in 1985 below the water table, with a total capacity of $4.3E^6$ cy. The landfill is a horizontal expansion of an old dump, and was designed with a full leachate collection system and a clay liner. No lysimeter was placed under the clay liner because of high water table.

TABLE 1

LEACHATE COLLECTION SYSTEM AND CLAY LINER DESIGN AT THE SELECTED MSW LANDFILLS

PARAMETERS	SITES			
	EAU CLAIRE	DANE	SAUK	METRO-S40
FLOW DIST. (ft)	100	150	150	150
LINER THICK. (ft)	4	5	5	5
LCS SLOPE (%)	2	2	4	2
CLAY PERMEABILITY (cm/sec) (per construction documentation)	$1E^{-7}$	$2.0E^{-8}$	$4.5E^{-8}$	$4.46E^{-8}$

HELP Model Simulation

For HELP simulations, site specific climatological data (mean monthly temperature, and daily rainfall) and the as built hydraulic conductivity of the clay liner were used. Default values were used for other soil characteristics such as field capacity, porosity and wilting points. The simulations were run from 1974-78 to reach waste field capacity. The model was then run using actual climatological data from 85-89 with necessary adjustments for open and closed landfill areas.

Analysis of Data

Field leachate volume data were expressed in inch/acre and are summarized in Table 2. Yearly and monthly leachate generation volume for the selected landfills are shown in Figures 1 and 2 respectively. The leachate volumes predicted by the HELP model are included in Table 3. The percent error in predictions, included in Table 4, were calculated using the following formula:

$$\% \text{ error} = \frac{(\text{observed} - \text{prediction}) \times 100}{\text{observed}}$$

RESULTS AND DISCUSSION

This section includes a discussion regarding the yearly status of each landfill (open vs. closed) used for the HELP model input and the assumptions made for prediction purposes.

Leachate Generation Rates

The leachate generation rate at Eau Claire, Dane, Sauk and Metro-S40 landfills are presented in Table 2.

TABLE 2

LEACHATE GENERATION RATES (IN/AC/YR) AT THE SELECTED LANDFILLS (1980-89)

YEARS	SITES			
	EAU CLAIRE	DANE	SAUK	METRO-S40
1980	3.53	----	----	----
1981	2.33	----	----	----
1982	2.98	----	----	----
1983	3.73	----	2.91	----
1984	3.06	----	3.26	----
1985	3.41	8.11	3.52	5.67
1986	2.21	2.45	5.77	3.84
1987	3.20	1.76	5.00	1.73
1988	1.50	1.69	4.76	1.02
1989	1.19	1.97	4.01	0.76
Avg:	2.71	3.20	4.18	2.60

Note: ---- indicates Site not operational.

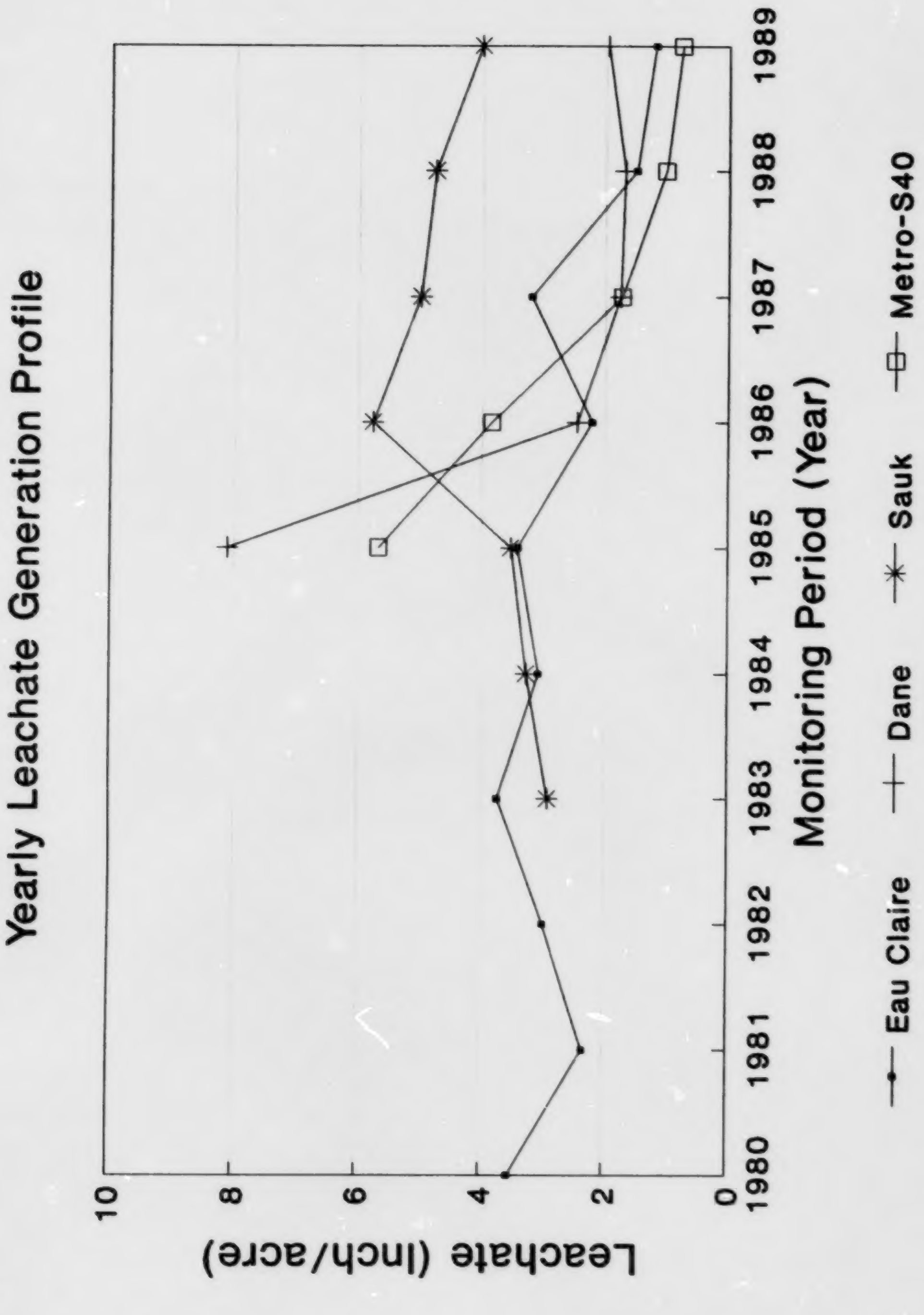

Yearly Leachate Generation Profile
Leachate (inch/acre)
10
8
6
4
2
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Monitoring Period (Year)
Eau Claire
Dane
Sauk
Metro-S40

Figure 1

At the Eau Claire County landfill, the leachate generation rate fluctuated between 1.19 (1983) to 3.73 (1989) inches/ac/yr, with an average of 2.71 inches/ac/yr. From 1980 to 85, the site progressively opened and closed 4 phases. The fluctuation of leachate generation rate is a reflection of the landfill status variation indicated above. By 1988, the whole site had reached its final grade and was closed in '89. One can observe the decrease in leachate volume after a final cover (2 ft clay and 6 inches of top soil) was placed on the fill.

Dane County landfill reported high leachate generation rate in '85 with value as high as 8.11 inches/ac. As phase 1 closed in '87, one can observe that the leachate generation decreased (Figure 1).

Sauk County landfill operated its first phase from 1983 to '89. The long exposure of the open area to direct infiltration may account for the high leachate generation rate.

Metro-S40 was designed as "zone of saturation" landfill with compacted clay at the bottom and side walls. The leachate generated at the site fluctuated from 0.76 (1989) to 5.67 (1985) inches/acre/yr (Table 2), with an average of 2.60 inches/ac/yr. Although completely open, the leachate generation rate did not show high fluctuation (i.e., from '87-89) as observed at the Sauk County landfill (Figure 1). The use of clay soil as daily cover as well as the high waste height (about 100 ft at Metro-S40) may account for such low leachate generation rate.

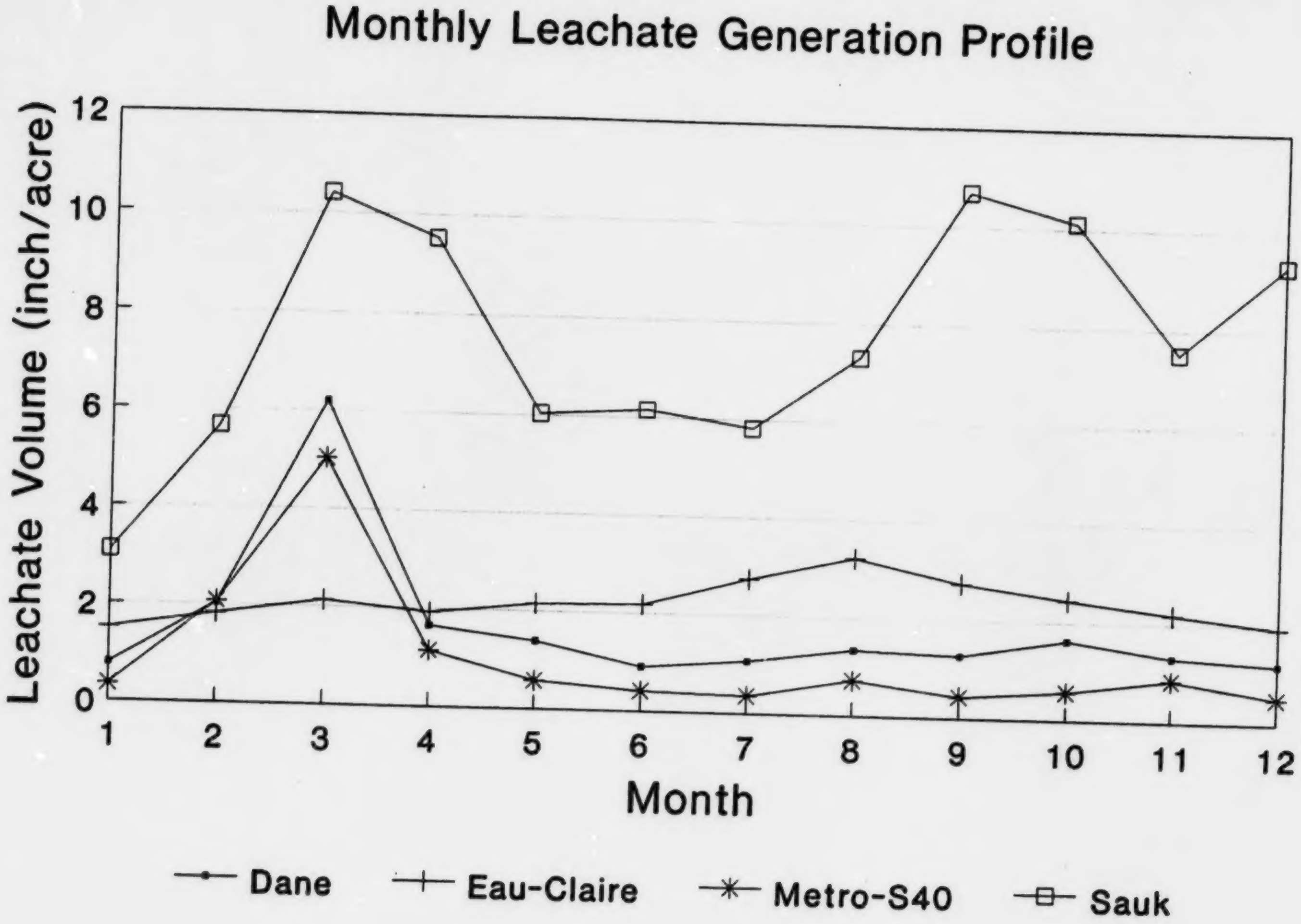
The leachate generation rates at all the sites show a low profile in January (winter months), a sharp increase in March and April which can be linked to snowmelt; in general, all landfills show high fluctuations in leachate generation rate during the site operating period (Figure 2).
There is a great variability in leachate generation rate from site to site.

Help Model Predictions

The following assumptions were considered during the HELP model simulations:

1) the different phases of the landfills used during the sequential site development behave as individual units.
2) the rainfall and temperature conditions at the weather stations are similar at the selected landfill sites.
3) open landfill phases are assumed to have reached their maximum waste height throughout the simulation period.

The input soil data for HELP simulations are presented in Table 3.



Monthly Leachate Generation Profile

1989 Data

Figure 2

TABLE 3

SOIL CHARACTERISTICS DATA USED FOR THE HELP MODEL RUNS

SITES	PARAMETERS					
	LAYER #	TH	WP	PS	FC	KC
EAU CL.	1	6	0.085	0.453	0.190	$7E^{-4}$
	2	24	0.288	0.430	0.366	$1E^{-7}$*
	3	600	0.140	0.520	0.294	$2E^{-4}$
	4	12	0.058	0.457	0.13	$1E^{-3}$*
	5	60	0.280	0.430	0.366	$1E^{-7}$*
DANE CO.	1	12	0.135	0.501	0.284	$1.9E^{-4}$
	2	24	0.290	0.400	0.366	$2.0E^{-8}$*
	3	1020	0.140	0.520	0.294	$2.0E^{-4}$
	4	12	0.58	0.450	0.131	$2.1E^{-2}$
	5	60	0.290	0.400	0.366	$2.0E^{-8}$*
SAUK CO.	1	1080	0.140	0.520	0.294	$2.0E^{-4}$
	2	6	0.058	0.457	0.131	1.03^{-3}
	3	6	0.20	0.700	0.045	10.0 *
	4	60	0.290	0.400	0.356	$4.5E^{-8}$*
METRO-S40	1	10	0.135	0.501	0.284	$1.9E^{-4}$
	2	1320	0.140	0.520	0.294	$W.0E^{-4}$
	3	12	0.058	0.457	0.131	$1.0E^{-3}$*
	4	60	0.290	0.400	0.356	$4.46E^{-8}$*

TH: Layer thickness (inch); WP: Wilting Point (vol/vol); FC: Field Capacity (vol/vol); PS: Porosity (vol/vol); Kc: Hydraulic Conductivity of liner (cm/sec).

* Indicates Site Specific Data.

The predicted leachate generation rates for Eau Claire, Dane and Sauk county landfills and Metro-S40 Landfill are presented in Table 4.

TABLE 4

LEACHATE GENERATION AS PREDICTED BY THE HELP MODEL

YEARS	SITES			
	EAU CLAIRE	DANE	SAUK	METRO-S40
1985	1.02	7.66	7.16	4.04
1986	0.93	9.04	9.17	5.64
1987	0.81	8.15	8.73	5.82
1988	0.74	5.22	8.92	3.26
1989	0.68	4.88	7.86	3.31
Avg.	0.36	6.99	8.37	4.41

As shown in Table 4 the leachate generation rate predictions fluctuated widely from site to site. Dane and Sauk County simulations yielded high predicted leachate volumes, with values ranging from 4.88 (1988) to 9.04 (1986) and from 7.16 (1985) to 9.17 (1986) inches/acre/yr, respectively. Metro-S40 simulations yielded low prediction profile, with values ranging from 3.31 (1989) to 5.82 (1987) inches/acre/yr (Table 4). Eau Claire landfill simulations predicted even lower leachate generation rate, specially after the site closure in 1989. Comparing all the sites indicated a great variability in leachate predictions.

Leachate Generation: Field Observation vs HELP Model Predictions

The comparison between HELP model predictions and leachate field data was performed by calculating the percent error and is presented in Table 5.

TABLE 5

PERCENT DIFFERENCE BETWEEN OBSERVED AND PREDICTED LEACHATE DATA

YEARS	EAU CLAIRE[1]	DANE	SAUK	METRO-S40
1985	-69.97	-5.54	+103.56	-28.75
1986	-57.86	+269.20	+58.96	+46.78
1987	-74.76	+363.03	+74.72	+236.19
1988	-50.65	+208.83	+87.16	+220.14
1989	-42.60	+147.73	+336.14	
Avg.	-59.17	+196.65	+84.10	+162.10

[1] Complete site closure early 1989.

In general, HELP model predictions overestimated the leachate generation rates at the completely open landfills (Dane, Sauk and Metro-S40). The error fluctuated from 58.96 to 103.56 % at Sauk, from -5.54 to 269.2 % at Dane, and from -28.75 to +336.14 % at Metro-S40. The model consistently underpredicted the leachate generation rate for the Eau Claire County landfill with the error becoming low after complete site closure. The error varied from -50.65 to -69.90 % from 1985 to '88 when 19 acres out of 24 acres (80 %) were simulated as closed. In 1989, after complete site closure, the error dropped to -42.60 %.

CONCLUSIONS

The field data at 4 clay lined landfills have shown a great variability in leachate generation rates. High fluctuations were observed during the site operating period, while a substantial decrease in leachate generation rate was indicated after the site closure.

HELP model predictions also showed fluctuation at each site. In general the model overpredicted the leachate generation in preclosure condition. The HELP model appears to underestimate postclosure leachate generation rate. HELP model simulation considering the site sequential development and proper initialization of the waste field capacity as performed in this study appeared an appropriate procedure for narrowing the difference between the predictions and the field observations. Using such procedure, the model yielded reliable postclosure predictions.

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INNOVATION TECHNOLOGIES FOR SOLID WASTE MANAGEMENT
AND LEACHATE TREATMENT
AT THE
BURLINGTON COUNTY, NJ RESOURCE RECOVERY FACILITIES COMPLEX

Prepared for: Canadian Waste Management/Waste Tech '91 Conference
October 30 to November 1, 1991

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Introduction

Landfill leachate treatment can be a challenging problem to site managers of today's secure solid waste disposal facilities. Highly variable strength, and volume along with varying composition make most "conventional" treatment schemes marginally feasible to treat leachate and hauling leachate off-site is getting to be cost prohibitive. That's why the biophysical PACT[R] system was chosen as the heart of the leachate treatment plant at the Burlington County Resource Recovery Facilities Complex. The treatment system has proven to be extremely flexible and has successfully treated leachate from the site that is highly variable in loading and composition.

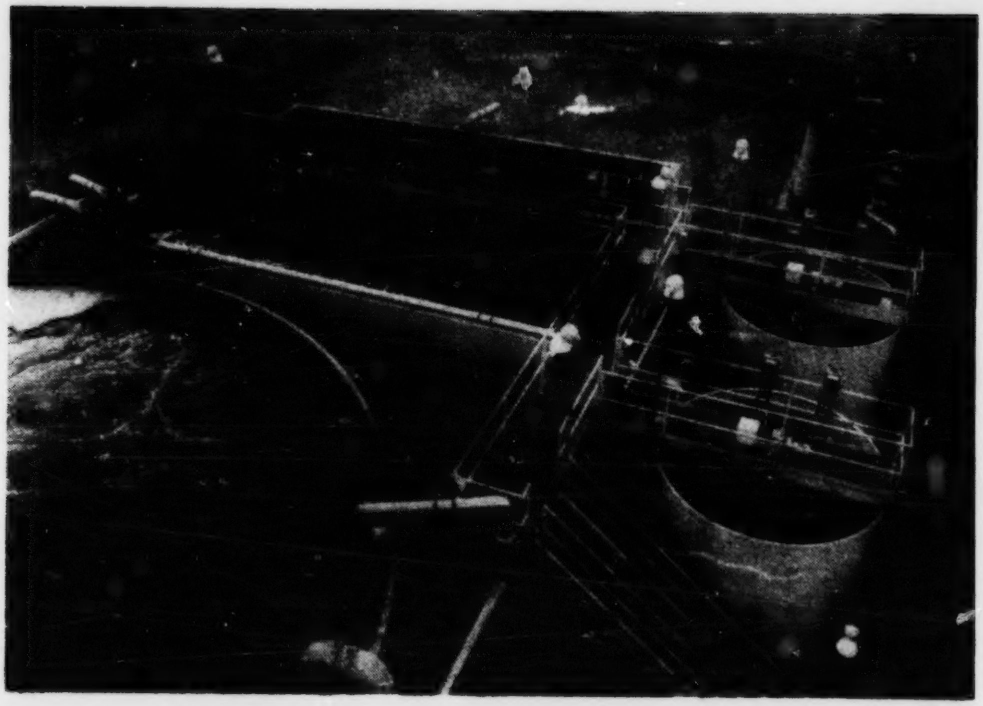
The new site near Columbus, NJ northeast of Philadelphia is combining several of the latest technologies for solid waste management including a recycling center, a permanent hazardous waste handling facility for household wastes, co-composting facility for solid waste and sewage sludge; a wood waste processing center and two planned greenhouses.

The 482 acre site is located on a major clay aquaclude. Secure landfill cells are now permitted for 54 acres. The solid waste landfill cells are designed to capture leachate for collection and treatment. The state of the art leachate treatment system is composed of metals precipitation followed by pH adjustment then bio-physical treatment to remove organics. A consistently high quality leachate effluent is disinfected then discharged to a small tributary at the Delaware River.

Since going on line in 1989, the system has proven itself as a reliable, efficient means of handling the widely varying leachate stream. The current site serves a population base of 400,000, however, expansion of the leachate treatment system is now being planned to accommodate the ever growing site needs.

Two 12 ft. diameter clarifiers separate the carbon/bio solids yielding a clean effluent which is disinfected (chlorinated-dechlorinated w/sulfur dioxide) then discharged to the Assiscunk Creek (a small tributary of the Delaware River). Clarifier solids are returned on a continuous basis to the aeration tankage to maintain a sufficient inventory of carbon/bio solids. Excess mixed liquor (or optionally, clarifier underflow) is wasted to an aerated sludge storage tank. These solids are thickened by periodically decanting and dewatered via a plate and frame filter press along with solids from the chemical precipitation pretreatment step.

To control odors associated with equalization tank mixing and leachate pumping operations, these areas are evacuated by blowers which discharge to the aeration tanks. Volatile organics are trapped on the carbon particles, thus holding these compounds within the aerated mixed liquor for bio-treatment.



PACT^R system provides flexible, reliable leachate treatment. First stage aeration basin in left foreground; second stage, rear; clarifiers, right.

Bio-physical Leachate Treatment

Leachate from the landfill along with sanitary waste from the various facilities is directed to a 30,000 gallon, air-mixed, equalization tank for load smoothing, see figure 1. Flow discharge from the equalization tank is pre-treated to remove metals via chemical precipitation using hydrated lime ($Ca(OH)_2$) and polymers. Just prior to entering the bio-physical treatment step the pH is adjusted to near neutral (7.0) with sulfuric acid. Solids removed in the chemical precipitation step are stored and then combined with excess bio-solids prior to dewatering on a plate/frame filter press.

The pretreated leachate (up to 50,000 gpd) then flows into the first of two aeration tanks where organic compounds are treated. In this step, adsorption and bio-treatment occur simultaneously. An aerated mixed liquor containing powdered activated carbon and active biomass physically adsorb and then metabolize organics to harmless carbon dioxide, water and new bacterial cell growth. The flow then enters the second aeration tank containing mostly powdered activated carbon slurry for a final adsorptive "polishing". Powdered activated carbon which is stored in a 2500 cu. ft. automated silo is added daily to replace the amount intentionally removed along with the excess biomass, thus a stable inventory is maintained. Carbon inventory can be adjusted to match plant loading to insure that the leachate is adequately treated.

BURLINGTON COUNTY RESOURCE RECOVERY FACILITIES COMPLEX BIOPHYSICAL LEACHATE TREATMENT SYSTEM PROCESS FLOW DIAGRAM

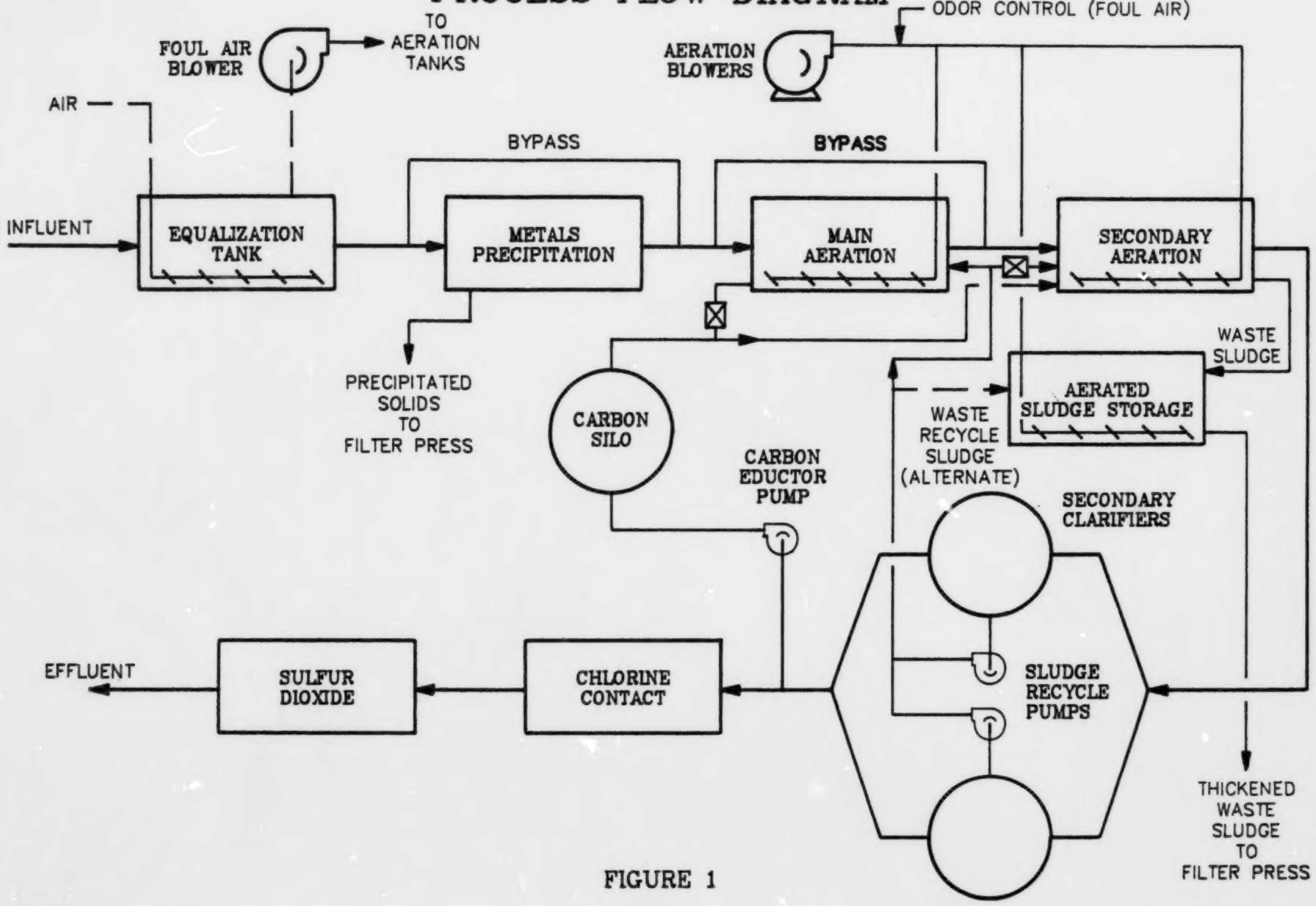

ODOR CONTROL (FOUL AIR)
FOUL AIR BLOWER
TO AERATION TANKS
AERATION BLOWERS
AIR
BYPASS
BYPASS
INFLUENT
EQUALIZATION TANK
METALS PRECIPITATION
MAIN AERATION
SECONDARY AERATION
PRECIPITATED SOLIDS TO FILTER PRESS
CARBON SILO
WASTE SLUDGE
AERATED SLUDGE STORAGE
WASTE RECYCLE SLUDGE (ALTERNATE)
CARBON EDUCTOR PUMP
SECONDARY CLARIFIERS
SLUDGE RECYCLE PUMPS
EFFLUENT
SULFUR DIOXIDE
CHLORINE CONTACT
THICKENED WASTE SLUDGE TO FILTER PRESS

FIGURE 1

Operating Experience

A multitude of factors determine the composition and volume of the collected leachate. Factors such as landfill age, rainfall, cell size, refuse composition and depth, and the ambient temperature all come into play. In order to maintain effective treatment of the leachate, operators of the plant adjust the concentration of carbon in the mixed liquor and the solids residence time (SRT) to compensate for loading variations. Carbon dosage rate can be held as low as 50-100 mg/L during periods of low loading. The dosage can be raised as high as 800-900 mg/L during high loading periods.

SRT is controlled between 15-20 days depending upon loading and leachate temperature. SRT of 20 days is normal for cold weather operation.

Nitrification is sustained under the relatively long SRT's enabling the plant to meet its ammonia nitrogen discharge limits.

Results

Typical results for removal of COD (chemical oxygen demand) and ammonia nitrogen are shown in the following data.

TABLE 1
LEACHATE TREATMENT RESULTS (MG/L)
(from monthly NPDES reports)

	COD Permit limit 100		NH$_3$ Permit Limit 20	
Date	in	out	in	out
4/90	1800	70	28.7	< 0.15
5/90	3100	68	48.1	< 0.15
6/90	2900	75	49.0	<20.0
7/90	4450	46	56.4	0.078
8/90	3625	20	50.1	0.425
9/90	1700	34	30.5	0.34
10/90	2054	28	39.5	0.25
11/90	1932	40	21.0	0.139
12/90	1436	49	23.1	0.213

The Future

In addition to treating leachate from the current landfill operation, the PACT system is scheduled to be expanded from its current 50,000 gal/day capacity to 130,000 gal/day. The future expansion will provide treatment for additional landfill leachate from the Burlington County Landfill leachate from the adjacent superfund site at the Florence Land Recontouring Landfill, sanitary and wash water from a new maintenance garage, leachate and condensate from a new solid waste/sewage sludge composting facility and sanitary waste from a new materials recycling facility. The future facility, once in operation, will represent a unique solution to a complex environmental problem.

Authors

Mr. Simpkins has coordinated the Burlington County solid waste management program since 1975. He holds a bachelors degree in environmental sciences from Rutgers University.

Mr. Depuydt is a graduate of Western Michigan University and has had several years experience in the waste management field, including five years working with the powdered carbon-biological system at Kalamazoo, Michigan.

Dr. Higgins is a graduate of Rutgers University of Illinois (M.S.). He is Vice President of Applied Wastewater Technology and an adjunct professor at Rutgers University. Dr. Higgins was the project manager at Alaimo Engineering Company responsible for design of the landfill, leachate treatment plant and associated ancillary facilities.

Processing Solid Waste at Landfills

(Le traitement des déchets solides
dans les décharges)

Richard Peluso
Wehran Environtech Inc.
Middletown, New York

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

REFUSE DECOMPOSITION AND *IN-SITU* LEACHATE TREATMENT

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ABSTRACT

Environmental impacts resulting from decades of solid waste mismanagement has led to major revisions in solid waste management policies. In order to prevent surface, groundwater and air contamination, solid waste management is now focused on source reduction, reuse, incineration and landfilling. The benefits of source reduction and reuse (recycling) are evident; the relative priority of landfilling versus incineration continue to be debated.

Landfill regulation and management, however, has focused on containment in order to slow or inhibit decomposition and production of leachate and/or landfill gas. This form of landfill management, however, will also lead to delayed refuse stabilization and extension of potential environmental impacts. Low permeability liners and caps prevent surface and groundwater infiltration into refuse thereby reducing the production of leachate. This procedure also inhibits microbial degradation of the refuse resulting in the creation of entombed waste materials, which may remain relatively unchanged for decades. By designing and retrofitting sanitary landfills to serve as active and effective bioreactors, solid waste will be more rapidly decomposed and therefore more readily stabilized. By designing effective leachate recovery systems, it is also possible to reduce the total contaminant concentration of the leachate.

As a result of a one-year study conducted at a large upstate New York sanitary landfill and a one-year week laboratory study of anaerobic treatment of landfill leachate in an upflow sludge blanket digestor, we've concluded landfills should be designed, operated and managed to promote refuse decomposition and *in-situ* leachate treatment.

INTRODUCTION

During early human settlement, household wastes were deposited on the streets, and/or in open areas or shallow pits in proximity to population centers. As long as the early settlements were of limited size, the impact on the environment was minimal because most of the wastes were readily decomposable or the direct impact to human populations was not recognized. As the size of the human settlements grew and wastes became more varied, there was a need to further isolate the dumping areas from population centers. During the mid-1800s the collection and disposal of municipal wastes became better organized. In 1856 Washington, D.C. implemented a tax supported, city-wide collection system (Melosi, 1981). Collected trash was removed from the communities, transported to areas in proximity to the urban centers and deposited in wetlands, floodplains, swales or excavated pits, abandoned quarries or other areas considered of limited use. In order to minimize exposure to rodents and birds, the wastes were periodically covered with thin layers of dirt or the refuse was burned in open pits. In the United States open burning of refuse was common practice until the mid-20th century. This practice was discontinued because of the stench resulting from the incomplete combustion of the wastes and the recognized health implications related to the extensive air contamination associated with this practice.

Up until the early to mid-1970s, the environmental impacts resulting from the improper disposal of municipal and industrial solid wastes were not well recognized. These wastes were treated similarly and deposited in mined out sand/gravel pits, quarries, floodplains or other low lying lands requiring filling and "reclamation" (Figure 1). The USEPA estimated there were more than 33,000 - 50,000 open dumps in the United States in 1986 (Brown, 1986). At that same time, it was estimated that there were more than 10,000 active landfills in the United States (Diegmueller, 1986). As a consequence, surface and groundwater contamination resulting from the improper disposal of municipal and industrial wastes became a serious environmental problem impacting the quality of drinking and recreational waters throughout the world.

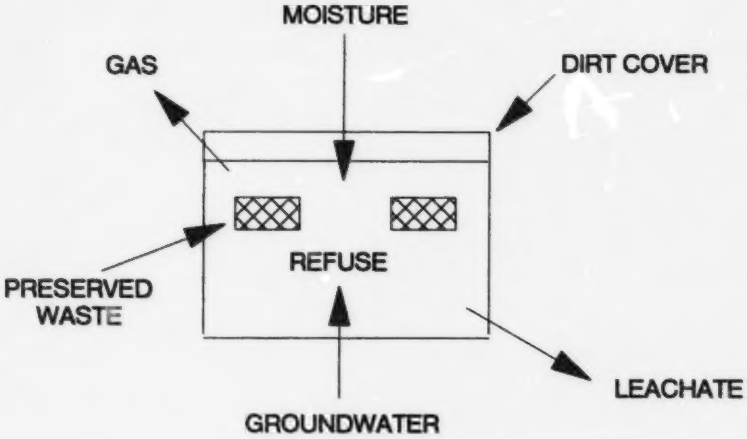

FIGURE 1. SCHEMATIC DIAGRAM DEPICTING THE DISPOSAL OF MUNICIPAL AND INDUSTRIAL WASTES IN AREAS CONSIDERED IN NEED OF RECLAMATION OR OF LIMITED USE. NOTE THAT THESE EARLY GENERATION LANDFILLS WERE CONSTRUCTED IN DIRECT CONTACT WITH THE SURROUNDING ENVIRONMENT.

The contamination of surface and groundwaters by industrial and municipal solid wastes prompted broadranging changes in the rules and regulations governing waste management during the 1970s. These changes focused on preventing surface and groundwater contamination by industrial and municipal waste leachates. In addition, municipal and non-hazardous industrial wastes were segregated from wastes either listed as hazardous or exhibiting hazardous characteristics. The generators of hazardous wastes in the United States are now required to maintain accurate records and control to ensure that these wastes are stored, transported, treated or destroyed in an approved and trackable manner. Although alternative management processes were initiated during the 1980s including composting, recycling and the increased use of incineration, sanitary landfilling continues to be the principle management option for most of the municipal and non-hazardous wastes generated in the United States. What has changed are the design and operational procedures for sanitary landfills. The principle changes imposed during the 1980s focused on the production and control of leachate with the objective of reducing the amount produced as well as its offsite migration.

With the industrial revolution, the variety and quantities of wastes increased significantly. The industrial by-products and wastes were co-mingled and deposited with the municipal refuse creating a complex admixture which posed a far greater threat to the environment. Leachates derived from these complex mixtures contaminated surface and groundwaters, including individual and municipal water supplies. More than any other factor, the widespread contamination of water supplies by landfill leachates led to sweeping revisions in federal and state regulations in the design and operation of landfills. In the United States, the sanitary landfills of the 1990s are being designed, constructed and operated to minimize leachate production in order to prevent environmental problems created by the thousands of dumps which have contributed to the widespread contamination of the Nation's water resources. These facilities are being designed and constructed with double composite liners, leachate collection systems, low permeable caps and design slopes to minimize infiltration of surface waters. In addition the newer landfills are designed to collect generated landfill gas which is either discharged to the atmosphere or is collected and used as a energy source.

LEACHATE GENERATION AND CHARACTERISTICS

The production of leachate in older generation sanitary landfills was dependent on the type, quality and character of the waste, the availability of surface and groundwater, the surface conditions of the landfill and the site soil and hydrogeology (Fungaroli et al, 1979). Because the new generation landfills are designed and constructed to isolate the refuse from the surrounding area, the availability of groundwater is less of a factor and the highly impermeable cap minimizes the importance of surface water infiltration. Additionally, because of the use of double composite liners, site hydrology is a less important potential source of leachate, at least in the short term.

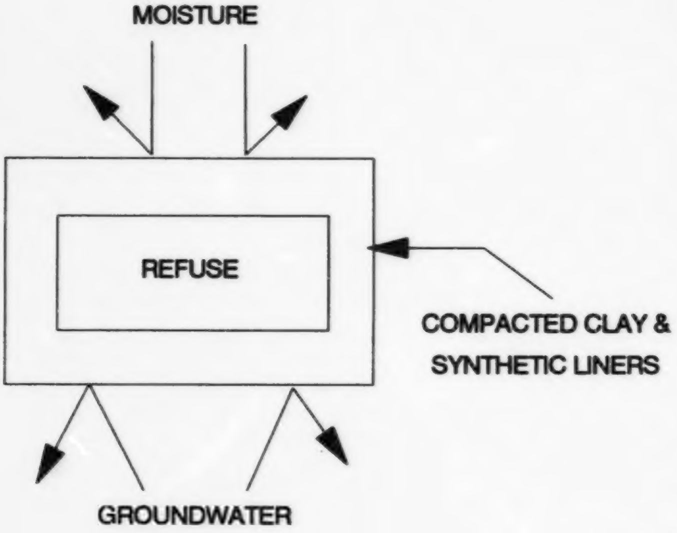

FIGURE 2. SCHEMATIC DIAGRAM OF THE NEWER GENERATION SANITARY LANDFILL WHICH INCLUDE DESIGN FEATURES TO MINIMIZE LEACHATE PRODUCTION AND CONTROL GAS COLLECTION AND USE.

Studies conducted on sanitary landfill leachate indicate it consists of a complex admixture of organic and inorganic compounds and trace elements. These studies have also demonstrated that landfill leachate can vary widely between and within landfills and it is not uncommon for concentrations of various constituents to vary by several orders of magnitude. For example, the biochemical oxygen demand (BOD_5) concentrations of sanitary landfills sampled during the 1970s were found to range from less than 50 to more than 50,000 mg/l; chemical oxygen demand (COD) from less than 50.0 to more than 75,000 mg/l; total organic carbon (TOC) from about 40 to more than 25,000 mg/l; total dissolved solids (TDS) from about 1000 to more than 27,000 mg/l. In addition, a host of trace organic and inorganic substances have been quantified in sanitary landfill leachates including a variety of volatiles, semivolatiles, pesticides and PCBs (Levine et al., 1989; Murray and Beck, 1990). Lead, mercury, cadmium and other trace metals are also common constituents of landfill leachates (SCS, 1976; Genetelli and Cirello, 1976; Lema et al., 1988). Landfill leachate will also vary with time and as the leachate ages, methanogenic processes reduce the concentrations of volatile fatty acids (VFAs), BOD, COD and TOC accompanied with a rise in the pH. Laboratory studies conducted on the anaerobic degradation of sanitary landfill leachates utilizing a upflow anaerobic sludge blanket digestor

(UASB) have demonstrated that as the VFA concentration of the leachate is consumed by methanogens, there is a corresponding increase in the pH accompanied by a partitioning of select trace metals from the liquid to the produced sludge (Pagano et al., 1991; Scrudato and Pagano, 1991). This phenomena was also noted in a field study of a large upstate New York sanitary landfill (Scrudato et al., 1990).

Shortly after burial, the refuse in sanitary landfills is subjected to aerobic biodegradation. During this phase the refuse and associated leachate will experience an increase in temperature resulting from the heat produced by the aerobic processes (Chian and DeWalle, 1977). As the aerobes consume the petrucibles, the available oxygen will be quickly depleted and the system will become anaerobic and maintain this condition until complete biodegradation has occurred or until oxygen is reintroduced to the system. The anaerobic processes within the landfill are initiated shortly after the facility is closed usually within a few months of closure (Barlaz et al., 1989). The moisture content of the refuse at the time of burial will also vary considerably and depends on the type of waste, the weather conditions during landfilling, the form of daily and intermediate cover and the site conditions (Leckie et al., 1979). Studies have indicated that the moisture content of landfill refuse should be at or near saturation to promote stabilization and gas production. When refuse at or is near saturation, landfill gas quantity and quality is increased appreciably due to more favorable microbial conditions.

With the implementation of more stringent rules and regulations governing the design, construction and operations of sanitary landfills imposed during the late 1980s, leachate management became an important factor in the overall management plan and requirements. The newly constructed landfills are designed to collect and recover the produced leachate in order to prevent contamination of area surface and groundwaters. Most of the leachate collected is currently being transported to area sewage treatment plants for disposal. It is estimated that more than 3.8 billion liters of leachate is generated annually in New York State (Morelli, personal communication) and most of that leachate is discharged to area surface waters through sewage treatment plants.

Despite the relative permeable conditions of the earlier generation landfills, refuse decomposition was not always promoted because of the highly heterogeneous character of the *in-situ* waste which often resulted in the development of conditions unfavorable to active biodegradation. Rathje (1991) has noted how little biodegradation occurs in many of the landfills located throughout the United States and references the recovery of 20 year old well preserved newspapers, hotdogs and other normally decomposable waste. These recoveries were made in areas of the United States which should be conducive to biodegradation because of ample rainfall. Yet, selective preservation of wastes occurred because biodegradable conditions within the landfill were not favorable. Pockets within the landfill were not receiving sufficient moisture and nutrients to actively promote biodegradation and the wastes were therefore preserved.

If the older generation landfills are capable of preserving wastes for more than 20 years, the newer facilities should extend the life of the biodegradeables well beyond that time period . The new generation landfill is designed to minimize leachate production and migration and since moisture content is considered one of the prime factors in promoting refuse degradation, the natural biological processes will be significantly inhibited resulting in the preservation of the degradable fraction and thereby forestalling waste stabilization. The newer generation landfill is also designed to effectively collect leachate with the use of subdrainage collection pipes and channelways. Because surface water infiltration will be minimized, the leachate produced in the newer generation landfills should be considerably enriched thereby contributing to increased contaminant loading to area sewage treatment plants. Additionally, as the refuse does undergo biodegradation, the anaerobic sludge and produced biofilm will tend to clog leachate channelways particularly as the life of the refuse is extended.

SUMMARY AND CONCLUSIONS

In summary, the new generation sanitary landfill has not been designed to rapidly stabilize refuse but rather will extend the time period that the facility will pose a threat to the environment. By slowing the biodegradation processes, the refuse will remain a threat to the environment well into the future thereby increasing the potential for failure of leachate collection systems which was the primary motivation for the newer generation design.

If the new generation landfill will ultimately lead to increased environmental threats, how should sanitary landfills be designed and operated? It has been suggested that sanitary landfills should be designed and operated from an ecosystem perspective (Figure 3). The facility should be managed to actively promote refuse decomposition and the production and use of the generated landfill gas. This would include maintaining the proper moisture, nutrient, pH, and temperature balances and ensuring that these essential components are evenly distributed throughout the refuse mass. Additionally, landfills should be designed to promote *in-situ* or on site biodegradation of leachate rather than continuing to use sewage treatment plants for leachate disposal. There is growing evidence that select trace organic contaminants will degrade under the proper anaerobic conditions (Brown, 1987) and select trace metals will be adsorbed by the sludge produced by anaerobic degradation of refuse and landfill leachate (Cameron and Koch, 1980; DeWalle et al., 1979; Mendez et al., 1989;). By actively promoting degradation of leachate and associated trace contaminants through the use of *in-situ* and on site treatment facilities, there will be a total reduction of trace contaminant loading to area surface waters.

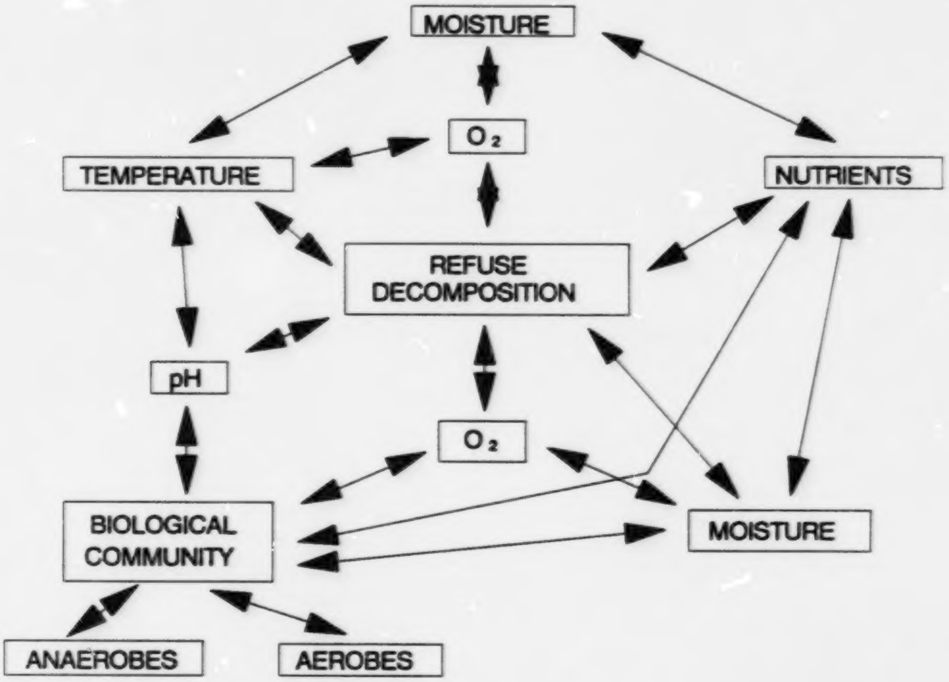

FIGURE 3. THE ECOSYSTEM APPROACH TO LANDFILL MANAGEMENT DESIGNED TO MAXIMIZE BIODEGRADATION OF THE REFUSE BY PROMOTING A FAVORABLE ENVIRONMENT FOR THE ANAEROBES.

The combination of accelerated refuse stabilization, *in-situ* or on site leachate treatment and enhanced gas recovery warrants far greater consideration. Since many newer generation landfills are currently being built without taking these factors into consideration, additional thought is needed on how these facilities might be designed or retrofitted to affect accelerated waste stabilization. One concept would utilize a retrofitted trench constructed within the refuse mass, providing a source of leachate for recirculation, as well as a reactor for the degradation of the leachate and a centralized gas collection system (Figure 4; Marsh et al., 1988).

Leachate recirculation is not a new concept. Pohland (1975) recommended recirculation as an alternative management practice and

Vasuki (1991) has been trying to effectively recirculate leachate in one acre test cells in the State of Delaware. Vasuki has gained a great deal of insight into the many problems encountered in promoting recirculation including clogging of leachate distribution pipes and distributing leachate uniformally within the refuse mass. What is clear is that leachate recirculation does promote refuse biodegradation and without moisture, refuse will remain relatively unchanged for decades thereby posing increased risk well beyond the post closure period.

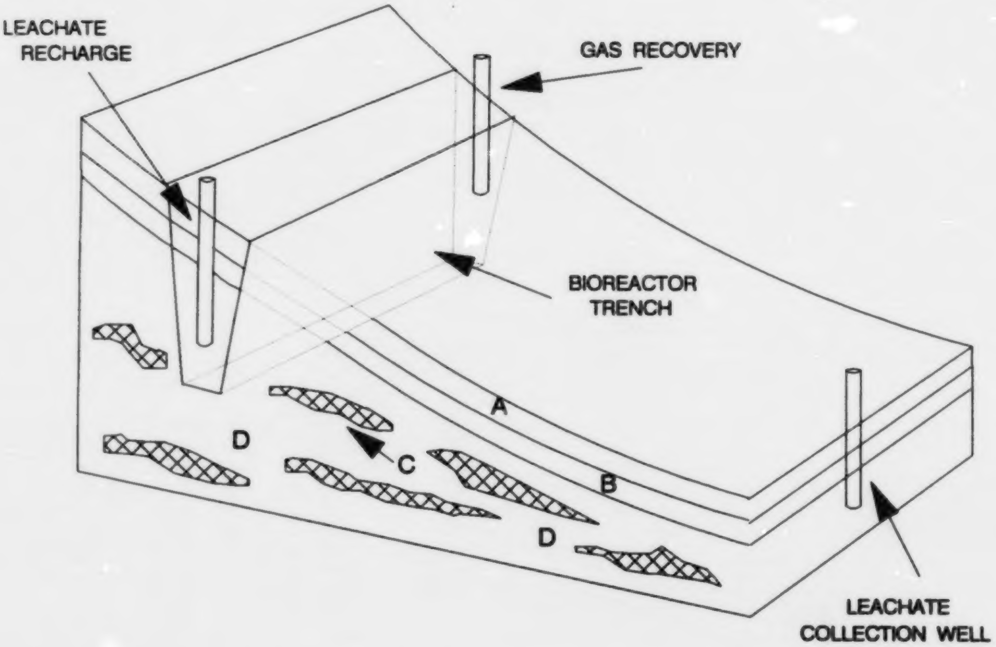

FIGURE 4. BIOREACTOR TRENCH SCHEMATIC TO PROMOTE LEACHATE RECIRCULATION, *IN-SITU* LEACHATE TREATMENT AND CENTRALIZED GAS RECOVERY. A = SOIL COVER, B = CAP, C = INTERMEDIATE OR DAILY COVER AND D = REFUSE.

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INTEGRATED SOLID WASTE MANAGEMENT & CENTRALIZED RECYCLING

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Background Information

The Resource Authority in Sumner County, Tennessee was created by private act of the Tennessee Legislature in 1979 and charged with the management of solid waste in Sumner County. Bonds backed by Sumner County and the cities of Gallatin and Hendersonville were sold to finance the construction of the existing twin-train waste-to-energy (WTE) plant. The plant has been operating continuously since December of 1981, with a nominal input capacity of 200 tons/day of municipal solid waste (MSW), and a nominal energy generation capacity of 54,000 lbs/hour of superheated steam and 550 kw of electricity. Steam sales are to three neighboring industries, and electricity is sold directly to the Tennessee Valley Authority (TVA). The Resource Authority also owns and operates a construction debris landfill and a state-of-the-art ash monofill. This makes Sumner County one of the few communities in the nation which does not involve the use of a raw garbage landfill in its solid waste management strategy.

The need to develop a plan of integrated solid waste management was demonstrated by two separate stimuli. The first stimulus was ineffective recycling. In 1981, recycling technology was extremely limited. A Nashville firm, National Recovery Technologies (NRT), was developing eddy current equipment to electromechanically remove aluminum from the waste stream. A contract was entered by NRT and the Resource Authority under which NRT appended a pilot plant onto the Resource Authority's WTE facility to process a portion of the incoming MSW to extract recyclables. As a demonstration plant, this facility was a success in that aluminum cans were successfully removed and that the process itself tended to improve burning efficiency and reduce wear and tear on the incinerators and boilers. However, less than 1% of the waste stream was being recycled, and the $10,000/month fee paid to NRT was not justified by benefits to the Resource Authority. In September of 1989, the Resource Authority's Board of Directors voted to cancel the contract with NRT and devote funds budgeted for NRT's processing fee to research available technologies and develop a plan for processing 100% of the waste stream for recycling. The goal was to recycle 20 to 25% of the total waste stream.

The second stimulus was the need to expand the Resource Authority's capacity to dispose of solid waste. The summer of 1989 saw periods in which the WTE plant could not process all of the incoming MSW. In addition, it was suspected that a significant quantity of MSW generated in Sumner County was being diverted to neighboring counties which have raw garbage landfills with lower tip fees. The population of the county multiplied by Tennessee's average per capita generation of MSW yields a current total generation of up to 300 tons/day. Moreover, projected growth patterns for the county indicate that up to 400 tons/day will be generated by the year 2000. In response to this clear need for expansion in the near future, the Authority's engineering consultant (NJC, Inc.) prepared a preliminary estimate of the cost of an additional 300 tons/day of WTE capacity. This projected cost of $30 million was felt to be difficult to justify, given the public's current expectations of waste disposal costs. Moreover, the latest set of Municipal Waste Combustor Regulations soon to be promulgated under the Clean Air Act make it clear that this cost may have risen further. Additionally, Tennessee's ***Solid Waste Management Act of 1991*** mandates that significant recycling must be in place by 1995. Investigations of recycling technology made early in this study indicated that the expansion of total capacity could be achieved at much lower capital cost through recycling and the production of a refuse-derived-fuel (RDF). At this point, the study to determine more effective methods of recycling and the study of solutions to capacity expansion could logically be combined.

Feasibility Study Objectives

In September of 1989, the Authority launched the above referenced feasibility study to determine the best solid waste management options for Sumner County. Consistent with this primary objective was the requirement to achieve the highest level of recycling which could be supported by available markets and economic realities. The authors also operated under a self-imposed requirement that the recycling methods chosen be sufficiently flexible to allow for low-cost adaptation to changing market demands for recyclables, future recycling technologies, and future development of recyclable products. To achieve these objectives, several recycling conferences were attended, numerous recycling and RDF plants were visited, and a fairly extensive literature search was completed. A large number of interviews was completed with potential users and marketers of recyclables, and data was collected from these individuals to develop a firm picture of market conditions and trends. The first step in determining what mix of solid waste management tools was best for us was to define and evaluate those components.

Available Methods of Waste Disposal

The most commonly used methods of solid waste disposal are landfills, mass burning, composting, recycling, RDF production, and waste reduction. A small amount of America's waste finds its way into construction materials, but the authors felt that this technology and these markets were not sufficiently developed to be included in this study.

Landfills

Not too many years ago, MSW landfills were perceived to be the long-term solution to America's waste disposal needs. Even today, such existing landfills remain the least expensive disposal alternative, with tip fees ranging from $4 to over $100 per ton. However, construction of a raw garbage landfill to satisfy Sumner County's MSW disposal expansion needs was not seriously considered for several reasons. The per ton cost of landfill disposal is on a steep upward trend. Over half of the nation's landfills will be full within five years, and the closing of these older landfills will tend to eliminate the tip fees on the lower end of the range mentioned above. The EPA has estimated that implementation of the new Sub-Title D regulations promulgated under the Resource Conservation and Recovery Act will add $15 per ton to the cost of landfill disposal. Moreover, many of the nation's older landfill operations include no reserve to cover the closure costs, long-term monitoring costs, and potential liabilities created by these new regulations. The City of Seattle projects $100 million for closure and monitoring costs on two recently closed landfills, and these landfills were closed before the new, tougher regulations were in place. For landfill operations without a closure reserve, future closure costs will only add to future disposal costs.

For many communities, the NIMBY syndrome has meant that MSW landfills are not feasible at any cost. Metropolitan Nashville has found it politically impossible to site a new landfill, despite stiff fines from the state's environmental agency, months of intense study, and numerous proposed sites with a sound engineering basis. Part of this public rejection is perhaps unfairly based upon the performance of older landfills with little or no engineering design. Today's engineering standards in conjunction with tomorrow's regulations should insure the promise of an ecologically sound MSW landfill, albeit at a much higher cost. Nevertheless, public rejection of MSW landfills is expected to intensify, not diminish. For example, the Authority's recent siting of a new construction debris landfill was met with strong public opposition (including death threats and gunfire), despite the fact that this landfill does not accept paper, household trash, or organic, toxic, or hazardous materials normally associated with leachate problems. This illustrates the public reaction which can be expected to new landfills of any type.

Mass Burning

Mass burning of MSW can be divided into two sub-categories: simple incineration and waste-to-energy (WTE) conversion. Simple incineration was not considered in this study because the economic recovery of energy from the burning of MSW has been thoroughly proven. The principal advantages of WTE plants over landfills have been the conservation of fossil fuels displaced by the energy generated in WTE plants and the significant reduction of net landfill space required to dispose of the ultimate residual of the various WTE processes. The most significant disadvantage has been higher capital and operating costs when compared to landfills. In some areas of the country, public opposition to WTE plants has been sufficient to derail otherwise sound projects.

A potential advantage of WTE is that, unlike a landfill operation, optimal WTE operations tend to encourage recycling. Removal of ferrous metals and other non-combustible recyclables raises the service factor of WTE feed systems, incinerators, and ash handling facilities, and significantly lowers the volume of ash produced. Most recycling systems will also yield an incinerator fuel which is smaller in particle size and more homogeneous, resulting in improved thermal efficiency. Removal of recyclable metals and plastics also reduces controlled emissions, improving air quality.

In Sumner County, the WTE plant has been a technological and functional success, but the revenues generated by steam sales have been an economic disappointment. The limited number of potential steam customers near the plant and the price structure of the existing long-term steam contracts have limited steam sales volumes and resulted in sales at rates well below market price. At the time these sales contracts were negotiated, natural gas prices were high and expected to go much higher. The price of treated steam was tied to the price of natural gas, and, as a result of depressed prices of natural gas, the Resource Authority in recent years has been forced to sell its steam for as little as 40% of the prevailing market. Since the potential to sell large quantities of steam at favorable prices does not exist near the Authority's facility, expansion of the WTE facilities as the primary means of increasing total disposal capacity was not as economically attractive as recycling and RDF production. This conclusion was further supported by the future impact of increasingly stringent environmental regulations. The EPA estimates that the latest round of air emission controls under the Municipal Waste Combustor Regulations will raise the operating costs of WTE facilities between $9 and $15 per ton. A first-pass review of these regulations indicates that the impact for the Authority's facility will be much smaller than this because it will fall under the less severe restrictions accorded to "small" plants. However, the examples of the MWC regulations for WTE facilities and the RCRA regulations for landfills point out the need for the solid waste manager to be sensitive to the potential economic impact of future governmental regulations when forecasting the economic basis for any MSW operation. Ideally, more reliance should be placed on those combinations of technology which are ecologically and economically prudent today, and show the promise of the least economic vulnerability to future regulations. The combination of technologies which was implemented by the Authority carries relatively small risk of increased operating costs due to regulatory changes.

Composting

While waste management through composting began right after God created vegetation, its use as a solution to the MSW disposal problem is relatively new. MSW composting facilities use a combination of pre-sorting, screening, shredding, turning, aeration, inoculation, and monitoring to reduce part or all of the MSW stream to a compost material for decorative ground cover, a soil mulch, and other related uses. (Note: This section deals with large-scale, centralized compost production; backyard composting of yard wastes will be discussed under waste reduction.) Although the potential of composting as one of the tools available to the solid waste manager is very promising, the long-term effectiveness of composting as a solution to MSW disposal is relatively unproven. The ultimate disposition of the refuse-derived compost may prove to be one of the most vexing problems introduced by this technology. It can be assumed that the capacity of landscapers, nurseries, and public works departments to consume refuse-derived compost is somewhat limited. If, for example, Metropolitan Nashville turned to composting as a primary solution to its present dilemma, it is difficult to imagine what middle Tennessee would do with 2,000 tons per day of refuse-derived compost. Just as old newsprint went from a high of $60/ton to a low of MINUS $47/ton due to expanding supply and limited demand, one could imagine a scenario in which the only available disposition for refuse-derived compost beyond a certain point was an artificial mountain.

Nevertheless, composting has potential environmental advantages which warrant the further development of the technology and the pursuit of markets for refuse-derived compost. The astute solid waste manager should ideally make no plans which would preclude the future adaptation to this technology. Most of today's recycling/RDF processes produce a fraction called "compostable materials". The composition of these materials varies from manufacturer to manufacturer, and from one location to another, depending on the composition of the waste stream. However, these "compostable materials" (or, "compost", as they are incorrectly identified by the equipment manufacturers) generally consist of dirt, grass, leaves, and food wastes, plus some paper and minus the magnetically-removed metals and recyclables which have been hand-picked. This shredded stream is indeed well suited for the composting process with little or no pre-sorting. In the short term, however, this stream will be more valuable to the Authority as fuel for the WTE plant, given the uncertainty of markets for refuse-derived compost and the certainty of revenues available to the Authority from existing steam contracts. But at the Authority's plant, these materials can be switched from WTE fuel to a compost heap at any time with no changes to the recycling facility. This has allowed the Authority to establish a pilot MSW composting program to optimize the process and establish markets for the output. We can easily switch to and from compost production on a daily basis. This is typical of the types of flexibility which are today crucial to successful solid waste management.

Recycling

By a wide margin, the "hottest" topic in the solid waste industry today is recycling. Recycling is correctly perceived by the public as ecologically vital, as well as a way to reduce the probability of having an unwanted landfill next door. In some cases, however, there is an improper public perception of recycling as a complete and stand-alone solution to the challenge of solid waste management. The public's predominate picture of recycling is curbside collection of materials separated in the home before the trash is hauled out. This vision is inaccurate because the majority of recyclable products is generated by commercial and industrial sources rather than residential, and because nothing is recycled until it is actually reused.

The two primary forms of removing recyclables from the waste stream are separate, curbside collection and Commingled Municipal Recovery Facilities (Dirty-MRF). In a curbside program, certain recyclable items are separated from the trash by the residential customer and deposited into one to four separate containers, then placed on the curb for collection. These pre-sorted materials are then transported to a central facility for further processing. In contrast, the Dirty-MRF approach collects all of the MSW with the current method and transports it to a central facility, where a combination of mechanical processing and hand picking removes the recyclables from the waste stream.

When comparing these two methods, many members of the public draw the initial conclusion that curbside collection must be cheaper than Dirty-MRF's, since a curbside program entails separation and sorting for which there is no labor cost. On the contrary, Dirty-MRF's have been shown to remove materials from the waste stream at a much lower cost per ton of material recycled. This is due to a much higher collection and handling cost in curbside programs, in that, in most cases, separate pick-ups are required by the municipal crews or independent contractor. Moreover, source separation and curbside collection do not eliminate the need for some type of labor-intensive central facility to further process the materials collected. For example, a few years ago Los Angeles completed two well-documented and extensive curbside test programs, the first with sorting of recyclables into two containers and the second using three containers. The net cost of removing recyclables from the waste stream was $107/ton and $111/ton, respectively. These costs were calculated after the landfill avoidance credits and revenues from sale of recyclables had been subtracted from the program's operating costs. An October, 1990 report from the New York City Department of Sanitation indicates their cost of curbside recycling to be as high as $273/ton. Nationwide, the net cost of removing recyclables from the residential waste stream through curbside collection in communities of a population similar to Sumner County ranges from $70/ton to $200/ton. By comparison, while some existing MRF's actually show a profit, one can expect a recycling cost from a Dirty-MRF in the range of $15 to $50/ton.

Another potential advantage of centralized recycling over conventional curbside programs is that it is not affected by that elusive and fickle factor of public participation. Successful curbside programs depend upon high rates of participation and the requisite public education campaigns. Similarly, when the economics of a particular recyclable commodity change drastically, it is relatively easy to add or drop that commodity at a Dirty-MRF. Such flexibility is generally absent from a conventional curbside program.

However, the two advantages of Dirty-MRF's described in the preceding paragraph point to one significant deficiency when compared to source separation: public education and public involvement. While the economic benefits of public involvement can be somewhat elusive, the social benefits are more apparent. For this reason, the Authority is implementing a "blue bag" co-collection program for source separated recyclables. Citizens will be encouraged to purchase Authority-endorsed blue bags at retail outlets, source-separate and deposit their recyclables into these bags, and then deposit these bags with their other trash for normal collection. This program captures the social benefits of public involvement while avoiding the costs of blue bins and separate collection. Meanwhile the Authority's recycling rates are not a slave to participation rates.

A third recycling method is voluntary drop-off centers, both manned and unmanned. The advantages of this approach include low capital costs and quick implementation. The net operating costs of these programs (per ton of recovered material) are generally lower than conventional curbside programs and higher than those of a Dirty-MRF. Potential disadvantages of unmanned operations include contamination and pilferage, while manning these facilities adds significantly to operating costs. Containers used include compartmentalized roll-off bins, specialized small buildings, and "igloo"-type containers. The igloo approach at unmanned sites usually results in lower contamination and pilferage, but it obviously costs more per month to empty a five-yard igloo than it does a 40-yard roll-off.

While the overall effectiveness of drop-off centers will vary from community to community, there is generally a segment of the public which prefers this method of recycling. The Authority purchased two roll-off trucks and associated bins to establish its first unmanned drop-off center. The trucks will also be used for short-haul delivery of certain recovered materials from the centralized recycling facility.

Regardless of the collection technique employed, recycling accrues a substantial ecological benefit. If a cost effective collection technique is used, recycling can also show a substantial economic benefit to the community. In Sumner County today, it costs about $48 to dispose of a ton of MSW. If a ton of recyclables can be removed from the waste stream for a net cost of less than $48, then the overall cost per ton of MSW disposal goes down, and the economic burden on the community has been reduced. The ecological and economic benefits of conserving natural resources through recycling are more national in scope, but they are just as real. Just as notable is the legislative trend mandating high levels of recycling and rendering economic and ecological arguments moot.

RDF Production

Production of fuel from municipal waste is a technology that has been around for about 20 years, and has obviously undergone changes in that period. Early RDF plants were designed and operated under the primary objective of reliably producing a low-cost fuel from the most desirable fraction of the waste stream. Little consideration was given to minimizing the volumes sent to landfills, and the consciousness of recycling as we know it today did not exist. Newer RDF technology is more accurately viewed as recycling/RDF technology in that it treats effective recycling as an integral part of the production of a high-quality fuel. Non-combustibles such as metals and glass and low-btu value combustibles such as leaves and grass must all be removed from the waste stream in order to maximize the heating value of the RDF and minimize its ash content. Plastics and heavy metals should be removed to minimize the environmental impact of burning this fuel. Other materials, such as computer paper and corrugated paper products, would have a positive impact on the RDF, but should be removed because they constitute benefit as a recyclable. Thus it is important to choose an RDF process which lends itself to flexible and efficient recycling operations. For example, the conveyor belt speeds and widths must allow the hand-pickers time to retrieve recyclables, and the depth of the MSW traveling down the conveyors must be shallow enough to expose the recyclables to the pickers. The various stages in the process must be designed with recycling in mind, so that there is access at critical points before and/or after the various shredders, screens, and air classifiers to retrieve recyclables before their value is diminished by further processing.

Refuse-derived fuel is a very low-sulfur fuel. Therefore using RDF to displace coal reduces sulfur dioxide emissions. Numerous tests have been conducted in the last four years which also show reductions in oxides of nitrogen and carbon dioxide. When the plastics in MSW are not removed, RDF burns with higher levels of hydrogen chloride, but this problem can be resolved by the use of a lime binder additive in the RDF, or by simply removing the plastics before the RDF is formed. Heating values of RDF range from 4,500 to 8,200 btu/lb, compared to a range of 11,000 to 13,000 btu/lb for coal.

Perhaps the most attractive aspect of RDF production is that it is an environmentally beneficial method of removing material from the waste stream before ultimate disposal. It has been shown that 45 to 50% (by weight) of the waste stream can be processed into RDF.

Obviously the RDF concept falls flat unless a home is found for the RDF produced. Unlike compost, the potential market demand for RDF is very substantial. For example, the Tennessee Valley Authority alone burns nearly 34 million tons of coal per year. If TVA were to displace only 4% of its coal with RDF, it would consume a volume of RDF equivalent to all of the RDF which could be produced by the entire State of Tennessee, assuming that 100% of Tennessee's MSW were being processed for RDF production. Any facility which burns coal, wood waste, or other solid fuel is a potential RDF customer, accruing the expected benefits of lower energy costs and reduced emissions. The Authority's staff worked closely with Senator Sasser, Senator Gore, and Congressman Gordon to encourage TVA to move as quickly as possible toward a pilot plant to evaluate RDF as an alternate fuel. In 1990 TVA published a pre-feasibility study concluding that it makes economic and environmental sense to pursue a companion boiler pilot project at one of its coal-fired generating plants which would consume between 600 and 1000 t/d of RDF. At the time of this writing, TVA has narrowed the list down to four potential sites, which are currently being further evaluated. There are other power generation plants which burn RDF exclusively, such as the 1300 t/d plant in Elk River, MN.

To reiterate, RDF production is an attractive component of integrated solid waste management. It promotes intensive but flexible recycling, it is environmentally beneficial when it displaces coal, it greatly reduces landfill consumption, it is compatible with composting, and it is perhaps the least expensive capacity expansion alternative, assuming that a market for the RDF can be established.

Waste Reduction

Perhaps the component of integrated solid waste management which makes the most sense for all concerned is waste reduction. A large portion of the materials which enter the waste stream are unnecessary in the first place, such as 24 cubic inches of packaging for 3 cubic inches of deodorant. Other materials can be beneficially recycled at the source without ever entering the waste stream, such as yard wastes and other organics which can be composted in the back yard. Economic pressure can be applied to the consumer to practice waste reduction through a multi-level trash collection rate structure which increases the charge with the number of containers set out.

The goal of achieving more sensible packaging is a more long-range one, and more national in scope, but this topic should certainly be included in the public education campaign. Consumers should be encouraged to purchase sensible packaging by being made aware that this would lower their waste disposal costs and conserve our natural resources. This concern should also be shared with your Washington delegation.

Seattle has instituted a multi-rate trash collection program under which the consumer contracts for one, two, or three containers of a specified size to be picked up at the residence. This program has the net effect of rewarding those consumers who practice waste reduction and providing a financial incentive for those who do not to change their ways. Implementing such a program in Sumner County was deemed impractical, since there are nearly 50 different trash collection contractors operating within the county.

Summary

Based upon these facts and conclusions, the Authority's Board of Directors resolved in March of 1990 to design and construct a centralized recycling facility to overcome the dual challenges of low recycling rates and insufficient disposal capacity. The Authority's three sponsoring governments were asked to guarantee the required funding, and these various approval processes were completed in August. On August 28, 1990, a $4,590,000 bond issue was sold. Functional specifications were prepared for the recycling equipment, and thirteen different companies purchased copies of the bid documents. Four firms submitted responsive bids. The bid utilizing equipment manufactured by the Lundell Company of Cherokee, Iowa was the best (and, happily, the lowest) bid. Construction began in December, 1990, and the facility was dedicated August 13, 1991. Start-up and performance testing began immediately after that, and the facility began operating on a full-scale basis (two shifts/day, five days/week) in October, 1991. The other components of the Authority's recycling plan (public education, "blue bag" source separation, drop-off centers, and composting) are scheduled to be in place by the end of 1991.

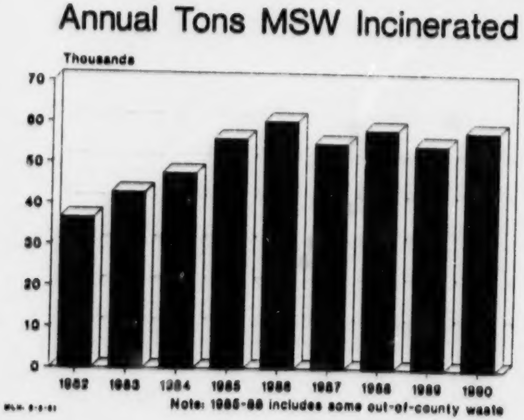
Resource Authority

- Created in 1979 by State law
- Joint effort among Hendersonville, Gallatin, & Sumner County
- Created to build WTE plant (in operation since 12/81)
- Independent Authority - minimal political interaction
- Does Not Use a Sanitary Landfill

MLH: 8-1-91

Waste-to-Energy Plant

7-Member Board of Directors

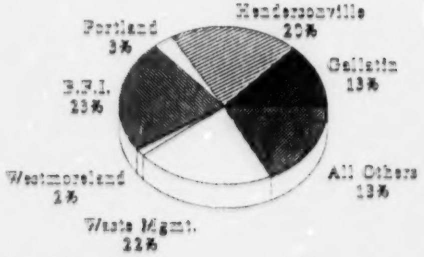


Annual Tons MSW Incinerated

Note: 1985-88 includes some out-of-county waste

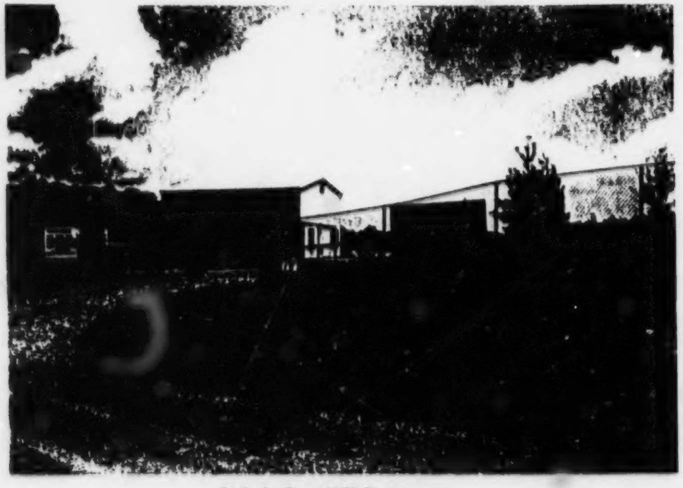
Resource Authority

Origins of MSW



Based upon data from 1-1-91 thru 3-31-91

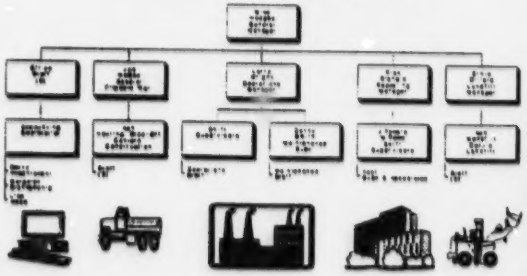
Ash Monofill



Debris Landfill Entrance

Debris Landfill Cell

Resource Authority
in Sumner County, Tennessee



Recycling Facility

Situation in 1989

- ✓ At capacity in summer (185 T/D)
- ✓ Minimal Recycling (<1% of MSW)
- ✓ Expansion option: 300 T/D WTE (@ $30 million)
- ✓ FY 88-89 deficit: $1.7 million

September '89 Board Meeting

Feasibility Study

Integrated Solid Waste Management:
The Next Generation

- Active Board Involvement
- Visited 15 Plants & Programs
- Attended 3 Conferences
- Involved our Congressional Delegation
- Met with local groups

MLH: 8-1-91

From Feasibility to Action

- Invoked Flow Control 1/90
- Feasibility Approved by Board 3/90
- Local Government Approvals 5/90-8/90
- $4.6 million Bond Issue sold 8/28/90
- Construction Begun 12/90
- Recycling Facility Dedicated 8/13/91

MLH: 8-1-91

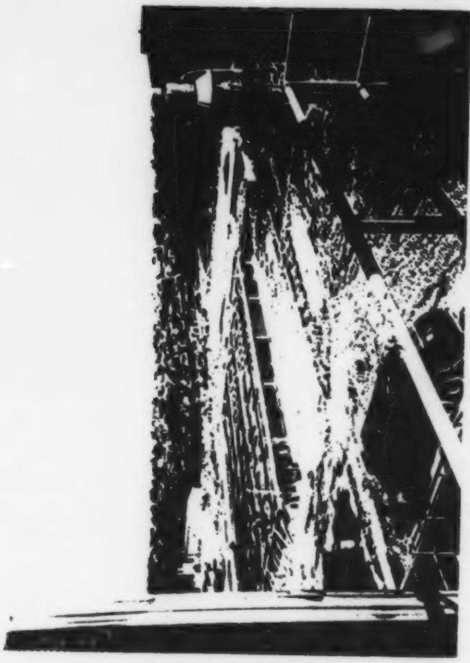
Construction Facts

Centralized Recycling Facility

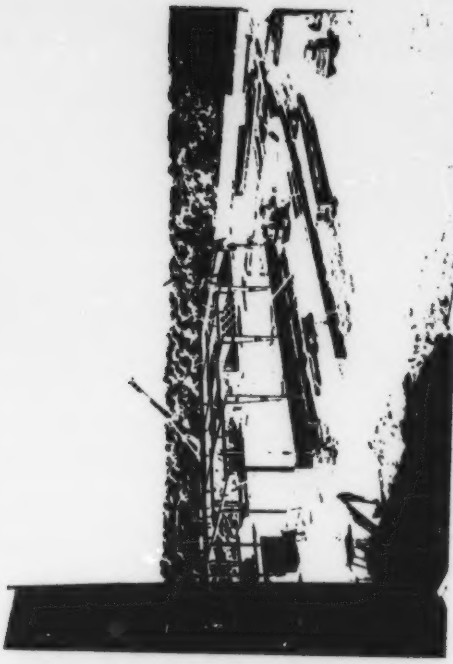
○ Five Acre Site
● 66,000 sq. ft. Enclosed (76,000 Under Roof)
○ 3,000 Cubic Yards Concrete
○ Clear-Span Steel Buildings
● Unique Basement & Conveyor Design
○ Fast Track Construction
○ Internal Construction Management

MLH: 9-3-91

Construction Progress - Groundbreaking



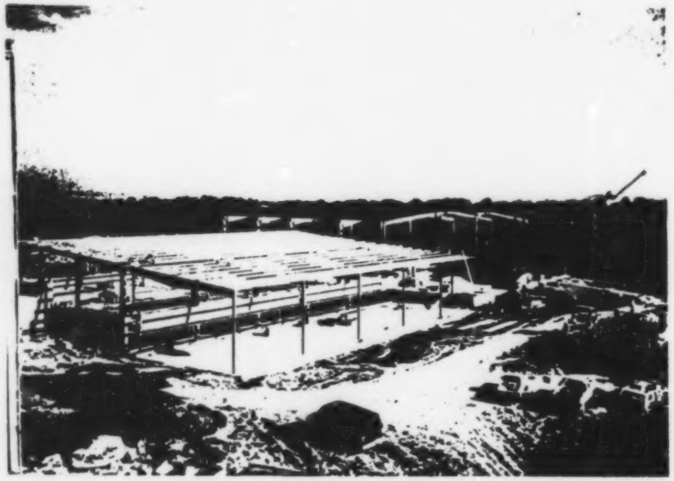
Construction Progress - Forming Process Floor



Construction Progress - Process Bldg Structure

Construction Progress - Basement Slab

Construction Progress - Start Steel Erection

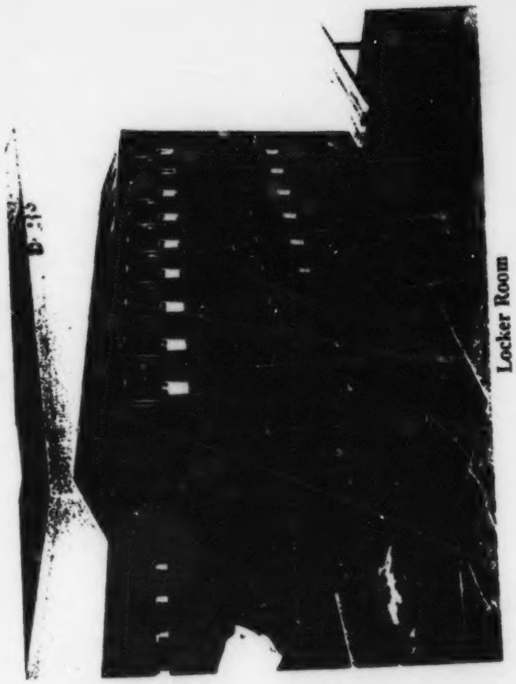


Construction Progress - Completed Structure

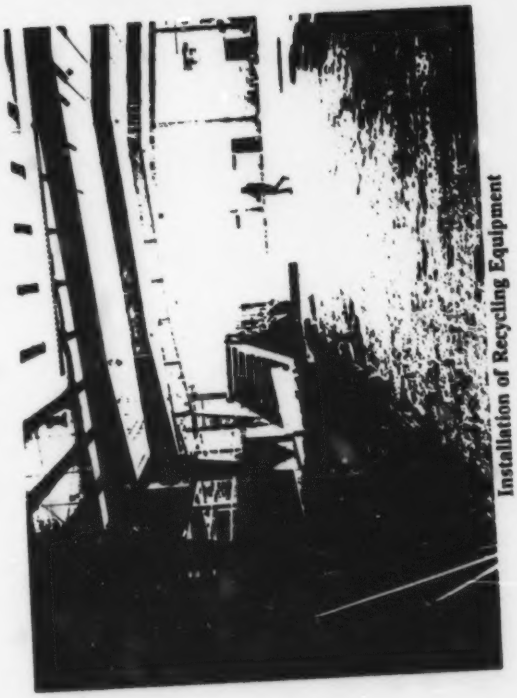
Construction Progress - Finished Product

Forming for Process Floor

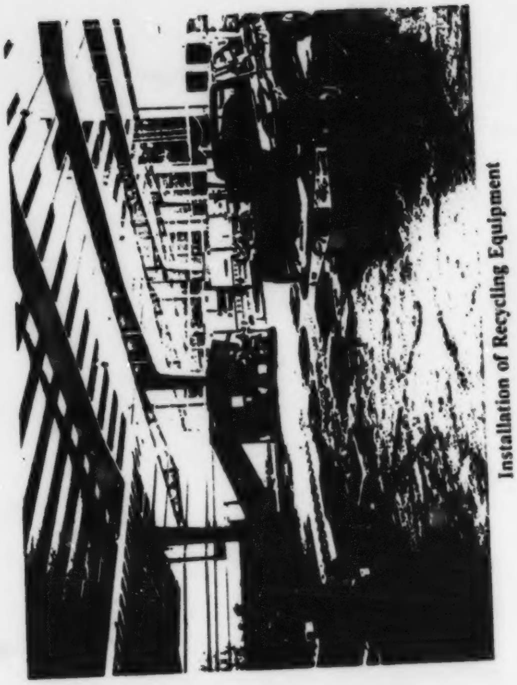
Steel in Process Floor



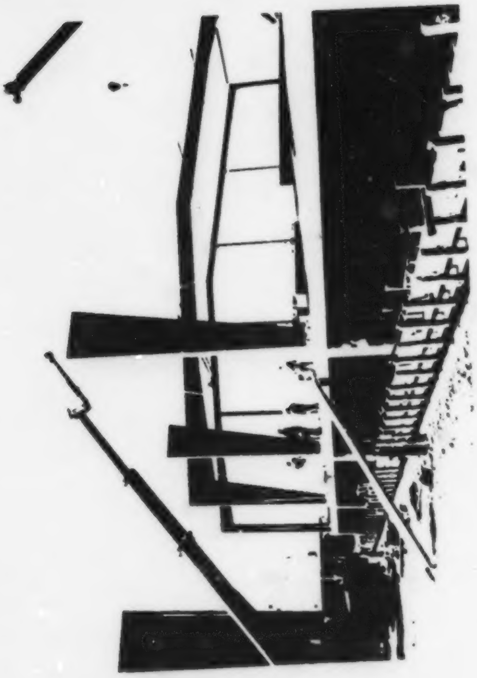
Locker Room



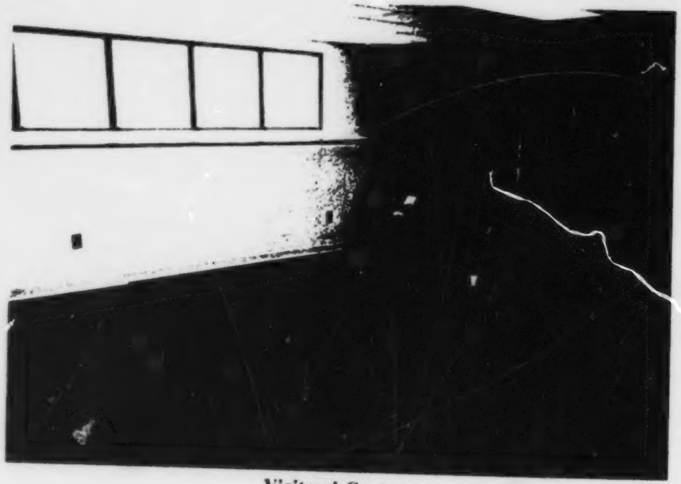
Installation of Recycling Equipment



Installation of Recycling Equipment

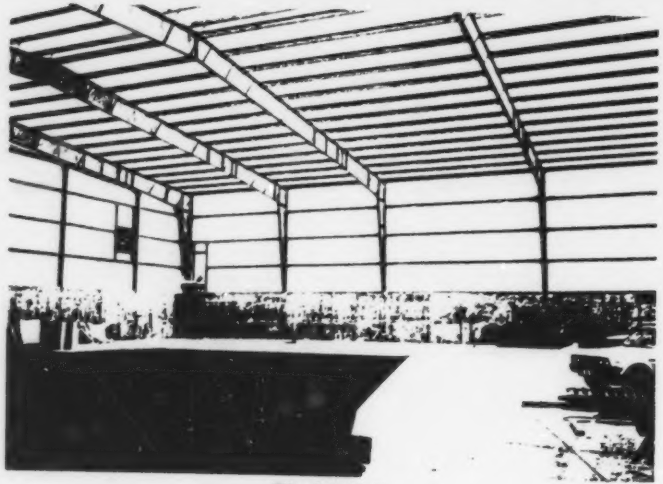


Steel Erection



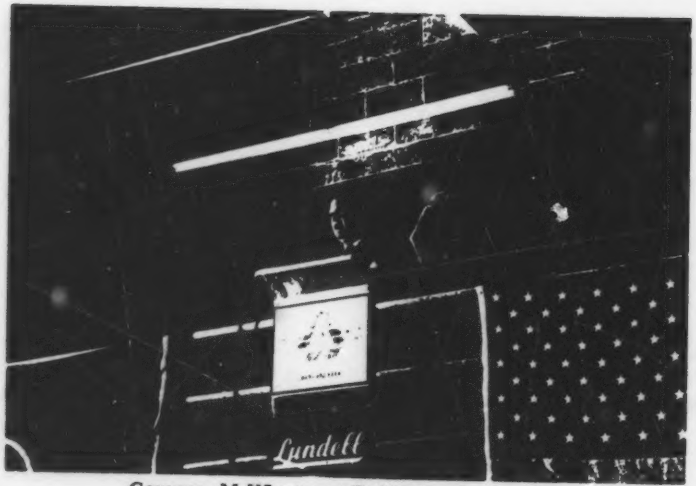
Visitors' Center

Break & Training Room



Tipping Hall

Erection of Conveyor to WTE Plant

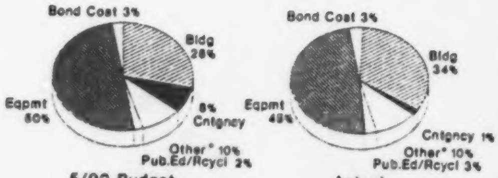


Governor McWherter at Dedication Ceremony

Luncheon After Dedication Ceremony

Project Costs

Planned vs. Actual

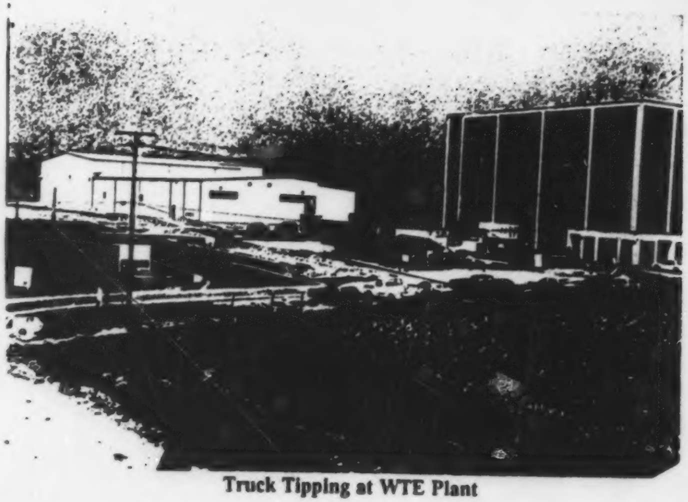


5/90 Budget
$4.26 M

Actual
$4.09 M

*Other: Engineering, Proj. Mgmt., Cap. Intr., Start-up

MLH: 6-2-91



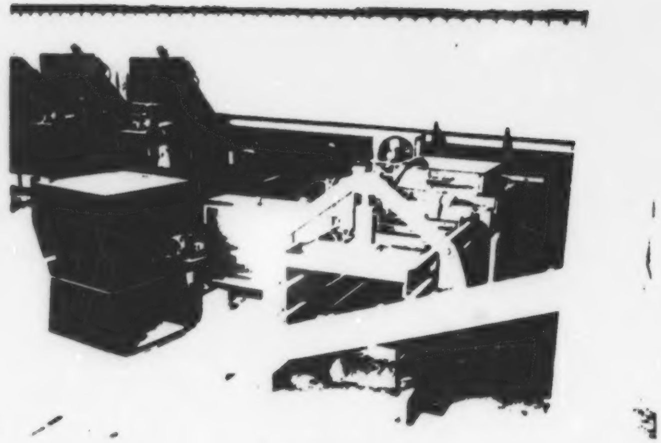
Truck Tipping at WTE Plant

Entrance to New Tipping Hall

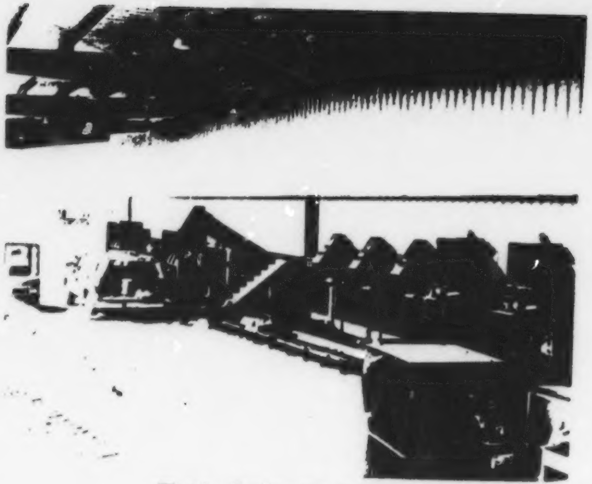
First Truck Tipping

Recycling Lines

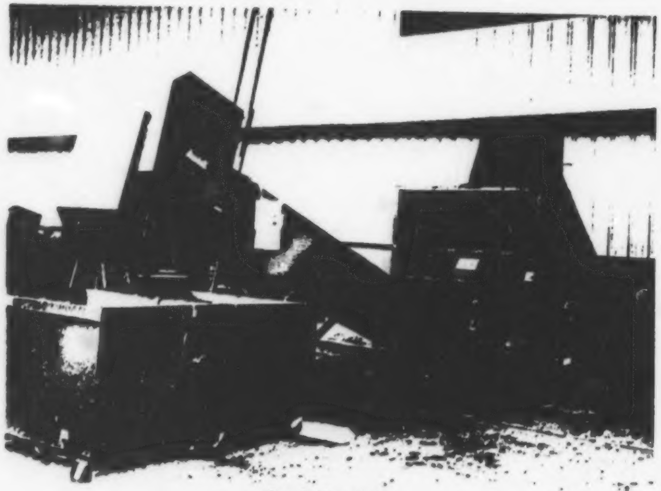
Manual Sorting



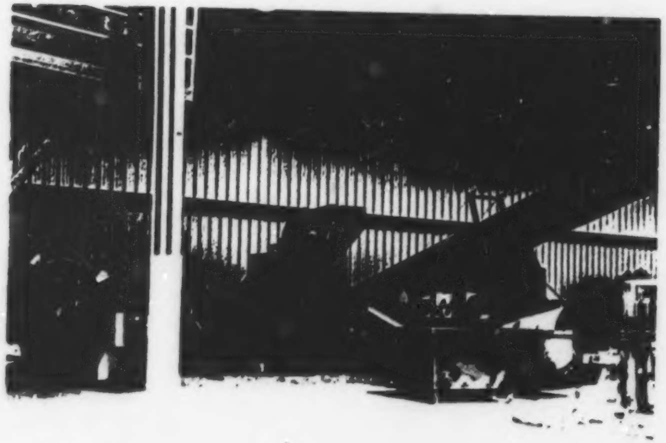
Automatic Baler



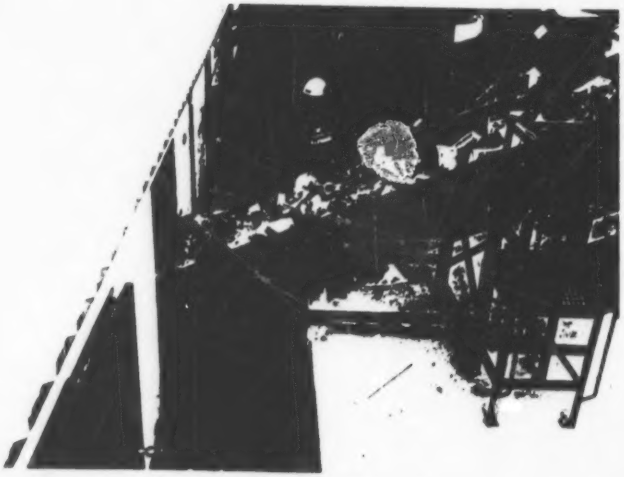
Plastics Perforators & Glass Crushers



Steel Shredder



Compost Shredder



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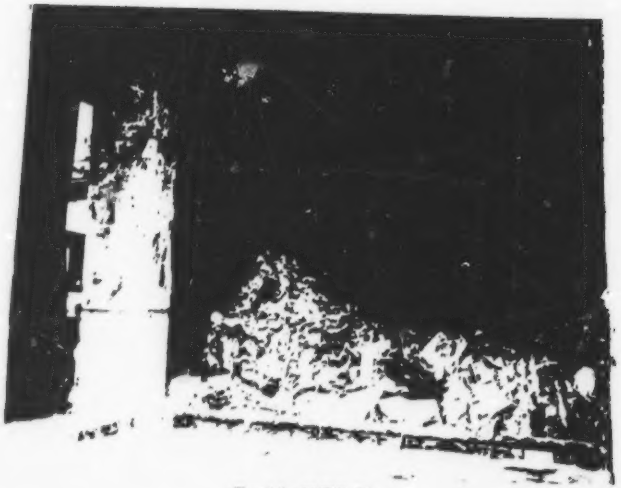

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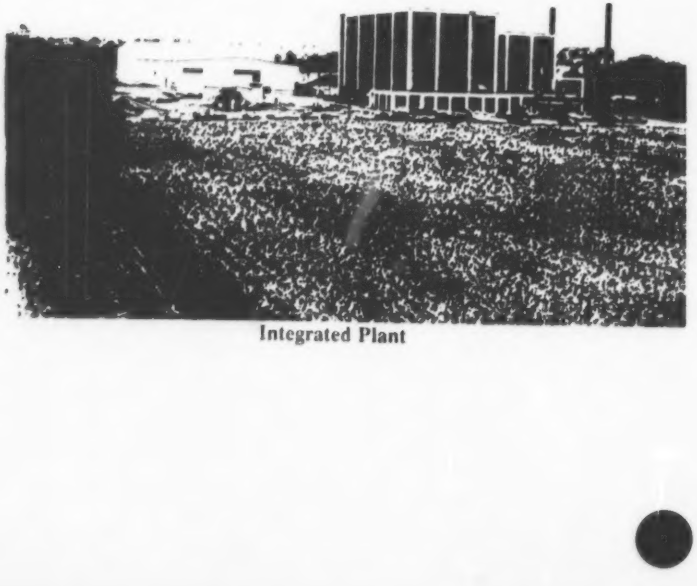

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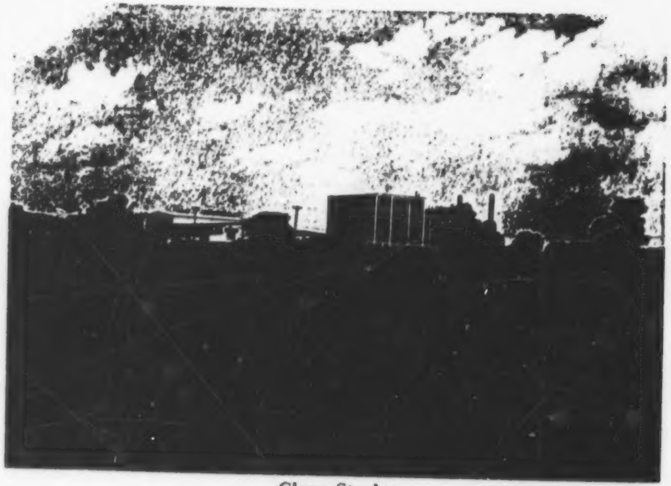

Clean Stacks

Policy Implications of Regional MSW Disposal: Process for Interstate Coordination

(Les conséquences de l'élimination régionale
des déchets solides mixtes sur les
politiques: méthodes de coordination
entre les états)

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THE STRUGGLE OF RURAL CALIFORNIA COUNTIES TO COMPLY WITH AB 939 (MANDATED WASTE DIVERSION)

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ABSTRACT

On January 1, 1990, California implemented a sweeping package of solid waste management legislation generally known as AB 939. Among the requirements of this legislation are mandated waste diversion criteria requiring that cities and counties, through source reduction and recycling, reduce the amount of wastes being landfilled by 25 percent by 1995, and 50 percent by 2000.

Although these mandates are ambitious for all types of jurisdictions, rural counties are facing particular problems in meeting these requirements. Lack of existing programs, small tax bases, distances from recycling markets, rural collection systems (or lack thereof), and unique waste-stream characteristics may present significant obstacles to meeting the mandated waste diversion percentages and/or compliance dates.

The requirements of AB 939 are summarized and rural county problems in meeting these requirements are defined and discussed. Two case studies are presented; El Dorado County (Cities of South Lake Tahoe and Placerville) and Tuolumne County (City of Sonora). The case studies discuss the challenges faced by the Counties, both unique and common to other rural counties, and alternatives selected to meet the legislated mandates. Recommendations are presented for approaching source reduction and recycling programs that will be most cost-effective for rural jurisdictions.

INTRODUCTION

Throughout the United States, legislators have become more aware of the growing solid waste disposal crisis and the potential environmental impacts that may exist from poorly constructed and managed disposal sites. In response, many states have passed legislation requiring that the amount of solid wastes generated be reduced by specific percentages, by specific dates. These waste reduction requirements are mandated by the states, but the burden of complying with the mandates generally falls upon the local jurisdictions; counties and cities.

In 1989, California passed a sweeping package of legislation generally known as AB 939 (Assembly Bill #939). This legislation became effective on January 1, 1990 and requires that all counties and incorporated cities "shall divert 25 percent of all solid waste from landfill or transformation facilities by January 1, 1995, through source reduction, recycling, and composting activities" (California Public Resource Code). "Transformation" means incineration, pyrolysis, distillation, gasification, or biological conversion other than composting. Likewise, AB 939 also requires a 50 percent diversion by January 1, 2000.

To achieve these diversion requirements, each county and city must prepare a new Integrated Waste Management Plan that outlines how the jurisdiction will implement programs to meet the requirements. Failure of a county or city to implement their plan may result in fines of up to $10,000 per day.

IMPACTS ON RURAL COUNTIES

It is generally agreed that AB 939 was intended to target large metropolitan areas where the majority of solid wastes are generated. A recent study conducted by the California Integrated Waste Management Board (CIWMB) concluded that, of the 58 counties within California, 34 "rural" counties occupy 51 percent of the land area, contain 7.5 percent of the state's population, and produce only 5.5 percent of the state's total solid waste stream (CIWMB, 1991).

It is also generally agreed that rural areas may have a more difficult time achieving the AB 939 waste diversion requirements. For this reason, the regulations state that a city or county may qualify for a reduced diversion requirement on the bases of "(1) The small size or low population density of a city or county, and (2) The small quantity of solid waste generated within the city or county". While this potential reduction may help many small cities, "Estimates indicate only three (of 58) unincorporated county areas meet both the demographic and waste generation criteria", (CIWMB, 1991). Therefore, most rural California counties (defined as those with populations less than 200,000) will have to comply with the full requirements of the regulations.

Rural jurisdictions are not only faced with complying with challenging diversion goals, but also may face certain problems and barriers that make these diversions more difficult. These include the following:

Revenues

Waste diversion programs, for the most part, cost money, although the public often believes otherwise. While it is true that these programs cost money in all jurisdictions, rural counties do not have the large tax base of metropolitan areas. Many rural counties are already having difficulty providing even the most basic community services, let alone developing and implementing completely new recycling programs and facilities. Once in operation, counties may also need to provide subsidies in order to keep the programs going. Additionally, new programs require more staff and that also means more money.

Raising sufficient revenues to implement new waste diversion programs, in jurisdictions with small populations, is more difficult than in larger population areas. The costs of constructing new facilities and implementing programs, while it may be less in smaller communities, is not linear. For example, a new material recovery facility (MRF) in a large city may cost $5 million dollars to design and construct. If the expense is spread among a population of 2.5 million people, the costs per individual would be $2.00 each. A rural county, however, may have 50,000 people and, although a small MRF could certainly be designed and built for less than $5 million, it probably would cost significantly more than $2.00 per person, or $100,000. Therefore, rural populations are more burdened in order to implement costly programs.

Finding ways to raise the additional revenues is difficult too. Increasing the tipping fees at a rural landfill will seldom provide sufficient funding to bring a major waste diversion program on line and support the operational losses. Increasing property taxes may be viable in some areas, but in California the taxes are limited by law. Direct payment for some programs by the users (e.g. for collection of recyclables) may be appropriate, but this seldom helps in the construction/implementation stage and may make new programs less effective.

Several rural California counties have resorted to assessing an annual solid waste fee to help fund solid waste programs. However, this is seldom a popular alternative in the minds of the public.

Staffing

A recently compiled report by Californians Against Waste (Smith, 1991) listed the first step in getting started toward waste diversion as "Hire your staff". Especially for rural counties this is a classic case of easier said than done. Not only do rural counties often have trouble attracting experienced solid waste personnel, the salaries they must pay to attract these candidates, which are in short supply, are very high compared to other county personnel.

Implementation Factors

Implementation of new recycling programs in rural areas presents additional problems. The long distance between residential and commercial waste generators makes waste collection more expensive than for urban settings. Compound that problem with additional collection needs for source separated materials, and small collection companies may not be able to recover sufficient revenues to stay in business. As waste collection rates increase to pay for additional equipment and labor, littering becomes more common, and because of the rural setting, litterers are less likely to be caught.

Many rural counties may have collection services that are either not mandatory, or not available in some areas. As much as 60 percent of the waste stream may be self-hauled to disposal facilities. In order to make an effective impact on the entire waste stream, diversion must address both the collection services and the self-hauled wastes, often leading to a need to have separate programs and facilities at additional cost.

Markets

Recycling markets, not surprisingly, have primarily developed near the major source of the materials, the larger metropolitan areas. Therefore, rural areas must transport these materials to markets and compete with much larger sources of recyclable goods. Often the cost of transportation is greater than the value of the materials.

In some cases, potentially recyclable materials may have no market value at all, but rural counties may still have to recycle these materials in order to meet diversion goals and the financial loss incurred is greater the farther the source is from the markets.

All of these basic impacts on rural jurisdictions may lead to difficulties in achieving waste diversion goals and it may seem an impossible task. There are many rural waste reduction programs underway, however, and some have met with great success. Other jurisdictions are just getting started and have developed plans to meet the diversion goals. Here are two examples of rural California counties and their approach to the mandated diversion challenge.

TUOLUMNE COUNTY

Tuolumne County is located in the central Sierra Nevada Mountains (Figure 1), has a population of approximately 50,000, and over two-thirds of the county's 2,217 square miles are federally owned lands (Yosemite National Park and Stanislaus National Forest).

In August 1990, a waste characterization study was conducted to determine the types and quantities of solid wastes generated in Tuolumne County. A summary of these results is given in Table 1 (EBA, 1991).

It can be seen from the waste characterization study that all of the standard recyclable materials (paper, plastic, glass, and metal) totalled 31.2%, less than the "special waste" category (37.9%), which was composed almost entirely of ash from industrial burning of wood waste. The second largest category was "other organics" (21.7%). This was composed of wood waste (11.2%), food wastes (6.8%), and textiles/leather (3.7%).

In early 1991, Tuolumne County was faced with less than two years of capacity remaining in the Jamestown Landfill, which accepts approximately 95 percent of the county's solid wastes. In an attempt to save remaining landfill space, several steps were taken to reduce wastes entering the landfill. First, all wood wastes and yard wastes were banned from landfill

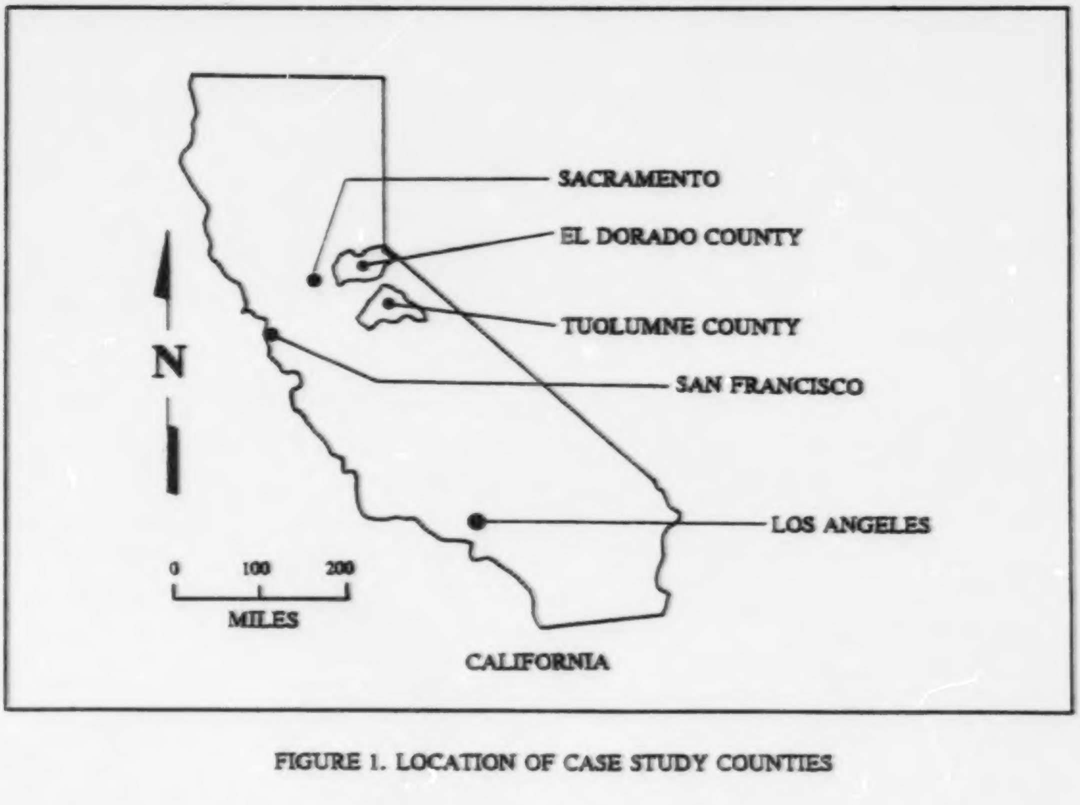

FIGURE 1. LOCATION OF CASE STUDY COUNTIES

TABLE 1. WASTE CHARACTERIZATION RESULTS
TUOLUMNE COUNTY, CALIFORNIA

WASTE TYPES (% by weight)		WASTE SOURCES (% by weight)	
PAPER	17.2%	RESIDENTIAL	28.6%
PLASTIC	6.6%	COMMERCIAL	30.0%
GLASS	3.0%	INDUSTRIAL	38.2%
METAL	4.0%	RECREATIONAL	3.2%
YARD WASTE	3.6%	**TOTAL**	**100.0%**
OTHER ORGANIC	21.7%		
SPECIAL WASTE	37.9%		
OTHER WASTES	6.1%		
TOTAL	**100.1%**		

disposal. This was feasible because one of the industries in the county accepts all wood and yard wastes for burning in their wood waste incinerator. This industry accepts the wood/yard wastes free of charge, so residents actually save money by taking the wood to the industry instead if the landfill, where a tipping fee is charged. This action diverted an estimated 15 percent of wastes from the landfill.

The second step was to encourage the two companies that produced ash wastes (36.4% of the waste stream by weight) to find beneficial uses for the ash so that it could also be removed from the waste stream. The two companies had already been working on alternate uses, especially as a soil amendment, and were willing to work with the county to eliminate the ash from the waste stream. One of the alternate uses included an agreement that the companies would blend the ash with soil and stockpile the material for later purchase by the county for final soil cover on the landfill.

By diverting the wood and yard wastes to industry and then diverting the ash to beneficial uses, the county has effectively reduced the waste stream entering the landfill by an estimated 51.2 percent. However, under AB 939 regulations, wastes diverted to incineration can be credited for a maximum of 10 percent diversion, and only counted toward the 50% diversion goal.

Other waste diversion programs underway in Tuolumne County include segregation of tires and metals from the waste stream, at the landfill. Tires (approx. 2% of waste stream) are loaded and shipped to an incinerator facility out of the county. Scrap metals (approx. 4% of the waste stream) are compacted, loaded and shipped to a scrap dealer out of the county. Both of these segregation/recycling activities lose money, but are subsidized by the county in order to maximize remaining landfill space.

Voluntary recycling by citizens has also increased during recent months. Two buy-back centers have seen significant increases in traffic and tonnage of materials. It is estimated that between 5-8 percent of the total waste stream is being diverted through the buy-back centers. The recent increase in voluntary recycling has been attributed to increased public education of the waste disposal problems faced by the county as a result of frequent local media coverage.

In summary, Tuolumne County has been very successful in diverting wastes from the landfill and the approach to achieving this diversion has not been through the implementation of standard recycling programs (curbside, composting, etc.). Most of the waste diversion has occurred by diverting special components of the waste utilizing local needs and resources. It is estimated that Tuolumne County has already achieved their 1995 goal of 25% diversion and, depending on what allowances may be made by the state, may be close to achieving the 2000 goal of 50% diversion.

Tuolumne County is also in the process of implementing curbside and commercial recycling programs, volume-based rate structures, and is planning to construct a materials recovery facility once a new, long-term disposal plan is developed and implemented.

EL DORADO COUNTY

El Dorado County is located in the Sierra Nevada Mountains, east of Sacramento (Figure 1). Although smaller in size (1,805 square miles) than Tuolumne County, El Dorado County has a larger population; approximately 127,000. The county is approximately 50 percent federal lands (El Dorado National Forest). El Dorado County has a diversity of demographic settings, with "bedroom communities" on the western side of the county nearest Sacramento, a large area of relatively low population density in the central part of the county, and portions of the Lake Tahoe Basin, with high recreational use, in the eastern area of the county.

Waste characterization studies were completed twice at both the Union Mine Landfill that serves the western areas of the county, and the South Tahoe Transfer Station serving the Tahoe Basin area. A summary of the studies is presented in Table 2 (CH2M HILL, 1991).

Unlike Tuolumne County, the waste stream in El Dorado County lacks the industrial ash component that made up a large percentage of Tuolumne County's wastes. El Dorado's waste stream composition more closely resembles waste stream composition

TABLE 2. WASTE CHARACTERIZATION RESULTS
EL DORADO COUNTY, CALIFORNIA

WASTE TYPES (% by weight)		WASTE SOURCES (% by weight)	
PAPER	31.4%	RESIDENTIAL	48.9%
PLASTIC	6.4%	COMMERCIAL	25.1%
GLASS	3.0%	INDUSTRIAL	18.6%
METAL	5.6%	OTHER	7.4%
YARD WASTE	8.2%	TOTAL	100.0%
OTHER ORGANIC	34.7%		
SPECIAL WASTE	0.8%		
OTHER WASTES	9.9%		
TOTAL	100.0%		

on a national average (Global Cities Project, 1991). One exception is that the "other organics" category constituted 34.7% of the waste stream, much of which was wood waste (19.6%).

To date, El Dorado County has taken a more conventional approach to waste diversion than Tuolumne County, primarily because the waste stream composition is also more conventional. Several drop-off and buy-back recycling centers are located in the county and it has been estimated that 17 percent of the waste stream is being diverted at this time. Approximately 91.6 percent of the diverted material is comprised of redemption value glass (39.4%), other glass (18.7%), aluminum cans (27.6%), and mixed paper (5.9%).

El Dorado County has also taken steps toward adopting volume-based collection rates in some areas of the county. Other areas of the County, however, still have unlimited volume residential service and local leaders are reluctant to abandon the unlimited service, even though it is direct conflict with the intent of AB 939. As part of the rate structures recently adopted by the county, a monthly fee was added to the residential and commercial service rates to fund residential curbside and commercial recycling programs. The residential recycling program will be developed to accommodate different areas of the county, with curbside separation being implemented in higher density areas and a commingled recyclable bag system for more remote areas.

El Dorado County also plans to construct a materials recovery facility within the next 2 years. With the combination of existing voluntary waste diversion, implementation of new curbside recycling programs, and operation of a MRF, it is probable that the county will achieve the 1995 diversion goal of 25 percent. However, it is unlikely that the county will be able to achieve the 50 percent diversion goal unless it can divert the wood and yard wastes from disposal. To accomplish this the county intends to implement a composting operation by sometime in 1995. The county will probably also need to divert tires (4-5% of the waste stream) and scrap metal wastes (4-6% of the waste stream), although these are not economical to recycle at this time.

In summary, El Dorado County faces a more difficult task in achieving the mandated diversion goals than Tuolumne County, primarily because the El Dorado waste stream is more similar to "average" waste streams and more conventional waste diversion programs must be implemented. These programs will tend to be more expensive and take significant lengths of time to develop and implement. In addition, the county must overcome the "unlimited service mentality" that exists in several communities in order to make programs effective. The county must also take steps to target the larger waste stream components in order to achieve the 50% diversion goal. This includes the estimated 27.8 percent of the waste stream that is wood and yard waste.

CONCLUSIONS AND RECOMMENDATIONS

Mandated waste diversion regulations provide challenges to all local jurisdictions. Rural areas may be especially challenged due to limited resources, smaller tax bases, lack of staff and difficulty attracting qualified personnel, and distance to recycling markets.

However, in some cases rural jurisdictions may have certain advantages that metropolitan areas do not. Unique waste stream composition may provide opportunities, rather than barriers, to effectively divert large percentages of the waste. Available and less expensive land may help in siting and implementation of waste diversion facilities and new recycling industries. Typically larger residential parcels help make backyard composting more practical, and certain local needs may exist that are unique to rural areas, such as the need for soil amendment, animal bedding, and hog feed, so that specific waste diversion programs can satisfy local demands without having to transport materials long distances.

In order for rural jurisdictions to effectively meet mandated waste diversions, several simple steps should be kept in mind. First; know your waste stream. While to some it may seem a frivolous use of limited funds, a well designed and executed waste characterization study is well worth the money. It can provide information not only on the waste stream content of certain recyclables (paper, plastic, glass, aluminum), but can specifically identify other waste components, sub-categories of wastes (such as the types of paper), identify where certain wastes are originating from (residential vs. commercial), and identify seasonal variations in the waste stream. Armed with this information, a rural jurisdiction can make intelligent choices regarding what programs will best suit the community.

Second; look for local resources that may be able to assist with waste diversion. Examples may include industrial facilities that can burn wood wastes, agricultural operations that may wish to use ash as a soil amendment, hog farms that may be able to accept certain food wastes, livestock facilities that may be grateful to have animal bedding, and nurseries and landscapers that would be able to use compost in soil poor areas.

Third; select potential programs that will best fit your waste stream and local needs. In some cases these programs may not resemble "typical" recycling programs and may be completely unique to your community.

Fourth; look for creative ways to fund the programs. In many cases waste diversion programs have not occurred because a capital expenditure is needed to get the system started. Often this expenditure is small by comparison to ongoing disposal costs.

Fifth; look for creative ways to lower facility operation costs. For example, a sorting facility is a labor intensive operation. In some areas incarcerated individuals may be used for such projects and this will greatly reduce the operational costs.

Sixth; try to work with neighboring jurisdictions in a cooperative regional effort. For example, in a three county area each county could be responsible for maintaining one type of diversion facility. The individual costs would be less than for developing multiple facilities in each county and the combined products of each facility would be more marketable.

Seventh; design "standard" recycling programs to meet the demographics of your community. What works in one community may not work as well in others due to differences in the waste streams, population densities, and even social attitudes. Include in these programs rate structures that will encourage participation. Also, attempt to design programs that will maximize the value versus the volume of recyclables. This is easier to do with smaller populations and smaller waste volumes and will help maximize the return (or minimize the loss) of these programs.

Eighth; rather than continuing to ship recyclable materials to remote markets, try to bring market industries to your area. Through a regional approach you can increase the appeal to industries. Additionally, industries may find that rural facilities are less expensive to develop and operate. This also has the added benefit of bringing more jobs to your community.

Ninth; plan ahead. Getting diversion programs implemented may be the biggest hurdle, but then you must be able to account for the amount of materials diverted. Areas with mandated diversion requirements will probably also have mandated reporting requirements.

Tenth, don't be afraid to be creative. Although the mandated waste diversion regulations were written primarily for larger metropolitan areas, that does not mean that rural jurisdictions should try to meet the requirements in the same way as the big cities.

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LANDFILL SITE PERMITTING IN RURAL AREAS: DEVELOPMENT OF RELATIONS WITH THE HOST COMMUNITY

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INTRODUCTION:

The landfill permitting process involves the use of environmental sciences to site and design a landfill facility to protect the environment. Establishing a scientifically supported site and facility design is today a necessary precondition to approval but only a starting point in project approval. The pervasive experience of host community resistance to landfill site projects based on perceived threats to host community interests and NIMBY (not in my back yard) attitudes points to the need for an effective development of a supportive host community relationship. The ability of a proponent to develop such a relationship with the host community will likely determine the success or failure of the permitting process.

The critical development of relations with the host community is substantially a matter or art rather than science. There is no single methodology or set of ingredients that can be identified. There are, however, some guiding principles that can help to shape a specific approach by a proponent to a host community. This paper will identify some typical obstacles to host community support and discuss the guiding principles and some potential features of a supportive host community relationship. While the paper reflects the experience of a private sector proponent of landfill projects, the lessons learned are largely translatable to the projects of municipal and other public sector proponents, as well.

1. THE KEY INGREDIENTS

THE PREREQUISITE OF ENVIRONMENTAL SAFETY

The development of a host community relationship cannot occur unless there are credible assurances regarding the environmental safety of the landfill operations and the direct responsibility of the proponent to prevent harm to the environment. The proponent must be openly committed to the highest standards of environmental safety in the selection of candidate sites and in the design of the landfill facility. There is a wide variance in the suitability of lands for waste disposal, particularly in respect of control of leachate and the protection of groundwater resources. The proponent should consider only the best possible soil conditions available to provide the disposal service contemplated. Environmental safety is a permanent responsibility of the proponent and once optimal site conditions are identified, the engineering design, operational standards, site monitoring and commitment to remediate conditions posing risk to the environment during site operations and post-closure must be clearly established.

For the proponent, environmental safety, as incorporated into site selection, design, operations and commitment to take corrective action as needed, are prerequisites that stand apart from any negotiation of the host community relationship. Although the proponent should have open consultation with the host community on the environmental safety issues the proponent must be forthcoming on environmental safety issues and refrain from using these issues as bargaining chips. There cannot be any trade-off of host community benefits for lower standards of environmental safety. The proponent must consistently demonstrate the prerequisite of environmental safety and the preeminence of environmental safety over all other issues to be discussed with a host community.

ESTABLISHING THE HOST COMMUNITY RELATIONSHIP

In recent years, much has been written about quality management techniques and the importance of customer service. The customer service model describes a business that is close to its customers by listening to their needs and concerns and adapting its product or service to be responsive to what their customers want. As a service organization, we must listen to our customers and provide them consistently with quality service according to their terms rather than ours, with value added. The first step toward developing a host community relationship is to treat the members of the host community, whether it is the municipality itself or individual residents, with the same level of concern and interest as we do our customers: adopt a caring and empathetic attitude, listen to their needs and interests, develop understanding and appreciation and respond with value added.

Genuine appreciation of host community concerns and a willingness to openly work with the host community to address the concerns will set the proponent on the path of establishing a host community relationship. While the customer service model serves the proponent well to develop a genuine caring approach and understanding of host community interests, it does not assist with resolution. While we can often address the needs of our customers on an individual basis, the host community relationship requires a total response. Within the host community, there are potentially a number of local stakeholders, e.g. residents' groups, local municipality, regional or area municipality and individuals who live or work near the candidate site or along local access roads. Each stakeholder may well have a unique set of concerns and needs. This is quite common and where it exists, there is considerable potential for distrust by a stakeholder of the proponent and other stakeholders if resolution of concerns occur between proponent and each stakeholder without the knowledge and participation of the other stakeholders.

To resolve the typically divergent interests of stakeholders in the host community, the stakeholders should be treated as partners with the proponent. In each host community a consensus needs to emerge about how stakeholders are to participate as partners. Although the details of partnership will vary in given situations, partnership entails host community participation in defining the nature and scope of the proponent's facility, in monitoring site performance and operating standards and by the host community receiving economic benefits, services and community facilities related to the success of the proponent's venture. The objective is that the host community perceive the proposed facility as justly responding to legitimate concerns and providing a net benefit to the well being of the local community.

The challenge of achieving a host community partnership is in achieving a satisfactory consensus amongst stakeholders with divergent concerns and priority of interests. Consensus may not be possible in some instances but the proponent must take the responsibility of seeking consensus on as broad a basis as possible, with apparent fair consideration of all stakeholder interests. Consensus can only emerge in an open process in which all stakeholders' needs are publicly identified and publicly responded to by the proponent. Responses to stakeholders must be perceived by all as fair and reasonable as between stakeholder and the proponent, as well as amongst each stakeholder. This will be much easier to establish if stakeholder interests can be confirmed as legitimate and the responses are made on an objective basis.

2. PROBLEM AREAS FOR A LANDFILL PROPONENT

Landfill projects typically are highly unpopular with candidate host communities, for a variety of reasons. Vigorous and emotionally-charged opposition is commonplace. For the proponent to define a facility concept and embark on developing a host community partnership, the typical problem areas must be understood. This section describes, from a number of perspectives, the major problem areas that can arise.

TANGIBLE LANDFILL IMPACTS

- leachate management	fear of groundwater and surface water contamination
- gas management	concern of safety from migration of methane gas and air emissions
- noise	nuisance effects of noise from site equipment and trucks accessing site
- truck traffic	safety concerns of trucks using local roads
- litter	escape of litter from site
- dust	dust from site operations and trucks accessing site
- birds	nuisance effects of attraction of birds and aviation concerns, if airport nearby
- odour	for odour emanation from exposed waste fill
- site aesthetics	visual impacts of exposed waste and landform presence

INTANGIBLE LANDFILL EFFECTS

NIMBY	Not in My Back Yard; social resistance to acceptance of waste produced by others
NIMTOF	Not in My Term of Office; political reaction by municipal council members
land conservation	loss of valuable land to waste disposal
property values	concern of lessened market value for properties near landfill site

SPECIAL RURAL CONCERNS

profligate urban communities	farmers regard themselves as conservationist and urban dwellers are seen as irresponsible and wasteful; the need for disposal capacity is seen as answering urban rather than rural sins
urban arrogance	urban communities refuse to take responsibility for waste disposal in their own communities, yet

blithely and insensitively seek to use rural landscapes as their dumping grounds

quality of life - some rural dwellers value highly the rustic, peaceful setting of the rural community, which will be disturbed by the nuisance effects of landfill operations and truck traffic

environmental sensitivity - rural communities depend upon groundwater for sustenance and for commercial farming

PROBLEMS OF TRUST AND CREDIBILITY

credibility of proponent - landfills are perceived as detrimental intrusions and proponent concern about operating practices and community interests is viewed as a temporary expedient that disappears once the permit is obtained

credibility of proponent's consultants - technical experts are perceived to be paid by the proponent for the purpose of supporting the proponent's permit objectives and cannot be trusted to disclose all the risks associated with the project

credibility of public bodies - environmental protection agencies and local governments may not be relied upon to ensure that local concerns are addressed

credibility of approval process - the formal process will not fairly and adequately address local concerns

3. MANAGING THE PROBLEM AREAS: DEVELOPING TRUST AND CREDIBILITY

The proponent's history of landfill operations is key to developing the trust of the local community in implementing the operational practices promised by the proponent. Employees of the proponent who will be responsible for the facility must be actively engaged in public consultation and not hide behind a team of consultants. Their personal integrity and genuine concern for community values will be assessed very closely by host community stakeholders as an indication of how the proponent will treat the community after the permit is obtained. The proponent must work to dispel the mistrust that its laudable attitude will disappear once the permit is obtained. Willingness to communicate on a permanent basis with the local community and willingness to involve the community in ongoing review and monitoring of landfill operations will help to establish credibility. Regular newsletters, a permanent information centre and the establishment of a landfill liaison committee with representation by provincial or state regulator, local municipality and local residents, will help create confidence that the local community is kept properly informed during the life of the landfill project and properly engaged with the issues of landfill operations.

Consultants should be carefully chosen for their technical competence and professional integrity. They can assist the proponent with evaluation of local concerns but should not subsume this role from the proponent. Consultants should be cognizant of the fact that their technical work must be utilized publicly with consideration for review by non-technical members of the public. Technical reports should be summarized for easy reference by non-technical people. Proponent provision for independent peer review of its consultant's key environmental impact work can be beneficial to the host community perception of the proponent's work.

The proponent can also be disadvantaged by poor credibility of regulators and local municipalities. It is of no help to the proponent that certain stakeholders lose faith in public bodies that have a role in the approval process. The proponent should maintain relationships with these public bodies in an open and arms-length fashion. Timely communication of relevant information by the proponent can help these public bodies do their work. Above all, the proponent must always respect the independent role and responsibility which might cause anyone to question the objectivity or integrity of a public body.

The approval process must be approached by the proponent with integrity and respect for fair hearing of local concerns. The approach to development of host community partnership will help to ensure that concerns are being received and fairly considered.

4. MANAGING THE PROBLEM AREAS: TANGIBLE CONCERNS

The major response by a proponent to tangible concerns is to return to the first key ingredient of environmental safety. Against this is a deeply instilled negative public perception of what landfills represent. There is, unfortunately, a legacy of bad experiences with land disposal of wastes. The bad experiences are due to a number of factors, principally:

- poor siting in unacceptable soil conditions
- inadequate site design to control leachate and gas
- poor operational practices to control nuisance effects, particularly inadequate cover practices to control litter, odour and unsightliness of exposed waste

The proponent should seek to demonstrate that modern landfills can be environmentally safe if high standards of siting, design and operational practices are observed. The proponent's site selection and facility concept must differentiate its project from the negative perception of garbage dumps.

5. MANAGING THE PROBLEM AREAS - INTANGIBLE CONCERNS

Even if the host community can begin to accept the proponent's assurances of environmental safety, there will nevertheless remain some intrusion into the rustic, peaceful rural community of noise, dust and litter from trucks and site operations. The intangible concerns over quality of life and providing a solution to someone else's disposal problems give rise to two common questions for the proponent: Why Here? and Why Should We Support This Project?

WHY HERE

Candidate communities will typically question why they should have been unlucky enough to be selected for a landfill site project. Surely, they think, there are other communities that are equally or more suitable for this project. Is it simply because their community leaders are weaker than in other communities?

A proponent, despite careful and appropriate site selection processes, will always be limited in providing an answer to this question that is fully acceptable to host community stakeholders. There are, however, some possible responses by a proponent:

1. Urban versus rural sites
   Landfill sites require large tracts of land as large buffer areas are needed to separate the rest of the community from landfill operations. Urban areas do not have large traces of undeveloped land available.
2. Natural site conditions
   Within the area the site is to service, a high priority must be on choosing soil conditions that maximize environmental protection. The preeminence of environmental safety eliminates many other communities from consideration.
3. Conservation of land and urban profligacy
   The proponent encourages waste management practices that divert waste materials from landfill through recycling, composting and other methods. The facility is based on a clear need for disposal capacity after waste reduction, recycling and reuse has been implemented as much as possible. The facility concept observes conservationist principles by incorporating recycling and composting, banning materials that can be recovered for reuse and by providing for a post-closure use of the land that will return its use to the community's benefit.
4. The community leaders are vigilant over community needs and concerns and are active to ensure that if the project is to proceed, environmental safety is ensured and there is benefit to the local community.

Ultimately, the host community relationship cannot be secured on the attempts to answer the question of Why Here? The proponent can indicate, however, that the decision to site in this community will depend greatly on a satisfactory answer to the second question which means that there is reasonable consensus amongst the stakeholders that the project is a beneficial one for the community.

WHY SHOULD WE SUPPORT THIS PROJECT

All land developments change the nature of the surrounding community and can be viewed often as mixed blessings - some amenities are given up in favour of new ones. The root of the landfill approval problem is that even with legitimate addressing of potential negative features, there are no benefits associated with a landfill that are perceived by the host community. There is no upside to the community which can motivate it to move from either passive acquiescence or opposition to a position of support. By way of comparison, residential development is perceived to bring new community services and municipal tax revenue. Industrial development is perceived, despite environmental impacts, to bring jobs and municipal tax revenue. The relatively modest contribution of landfills to local employment and municipal bases is viewed as inconsequential.

The development of a set of community benefits that creates some tangible benefits for the host community is at the core of the host community partnership approach. If the host community must bear some burden of an unwelcomed land use in their community, there should be a sharing with the community of the success of the project. The interests of proponent and host community become closely linked.

The selection of community benefits will vary considerably from one community to another according to the needs and priorities of the community and the economics of the project for the proponent. Fortunately, the trend in North America to much higher disposal fees allows proponents much greater flexibility to share benefits than before. This is tempered to some extent by advances in regulatory standards for landfill sites that increase the costs of operating and closing the site. The mix of possible benefits allows for considerable creativity in maximizing the perceived value to the community. It is important that the proponent not take the expedient approach of simply offering a large sum of money to a host community. The host municipality is an important stakeholder but not the only one. Genuine concern for people who live near the site or along local access roads should prevent the proponent from abandoning them in favour of an expedient resolution with one, perhaps more powerful stakeholder. The proponent neither wants to be accused of buying off opposition nor wants other stakeholders accused of selling out. Accusations may be made regardless but the proponent must establish a consultation and mediation process that is open and has integrity and the results obtained should have a tangible and objective connection to the local interests affected.

6. POTENTIAL ELEMENTS OF HOST COMMUNITY PARTNERSHIP

Consistent with the principle that environmental safety is a prerequisite for the proponent, the offer of benefits to the host community should neither preclude opposition at the approval hearing nor restrict stakeholders from calling into question at the hearing the position that the proponent has taken on environmental safety issues. The elements of partnership are intended to outline areas of agreement that are sufficiently conditioned on the grant of the permit and level of business at the site that stakeholders have incentive to support the proponent's application in principle. While they will be at liberty to raise issues and seek conditions to the permit approval, their ability to extract additional permit conditions, not related to environmental safety issues, will be practically limited. This is because the tribunal hearing the permit application will likely have respect for the process of consultation and mediation that is in fact open and has integrity, especially where the result of that process can be readily seen to be an objective accommodation by the proponent of divergent stakeholder interests.

Examples of elements that may form the essence of a host community partnership may include some of the following:

1. Waste disposal service

   A long term contract with host local municipality and/or host area municipality may be made for disposal at favourable rates. This is especially useful if the site is used for external waste as the agreement can effectively secure an indirect subsidy by external generators and municipalities of the local disposal costs.

2. Contract for collection and processing of recyclables and compostables

   The proponent should be careful that local disposal arrangement does not inhibit local efforts to divert waste from landfill. Such recycling services will be perceived positively by local residents. In addition, in many rural communities, collection service for waste and recyclables is not provided by local municipalities. The proponent could consider agreeing to collection service for landfill neighbours or make arrangements for convenient public drop-off of waste and recyclables.

3. Community facilities

   Recreational facilities and meeting centres are often lacking in rural areas. Buffer lands can be used for recreational and sporting purposes. Site buildings can include an education centre on environmental subjects and facility operations to be used in conjunction with facility tours. Meeting areas could also be included.

4. Community beautification
In addition to visually screening landfill operations and landscaping the site itself, some rural residents object to observing the change in topography resulting from above grade filling. Off-site tree planting and landscaping can provide additional screening and/or beautify the local community. Planting hedgerows along adjacent farm properties downwind from landfill operations can augment the litter control program.

5. Contribution to municipal services
A financial contribution to water or sewer projects and improvements to local access roads in areas near the landfill site may improve amenities for neighbouring property owners.

6. Royalty to host municipality
A compensation agreement can be struck with the host municipality. This can take a variety of forms. A per ton rate that varies according to the origin of the waste is one example. The fees paid may be tied to specific municipal purposes or projects or received into general revenue.

7. Royalty to trust for local residents
Residents and property owners who live near the landfill site or along local access roads do not consider host community fees payable to the host municipality to address their concerns or redress the impacts that they perceive. One approach is to pay all or part of property owners' municipal taxes. Another more sensitive approach is to a pay a royalty to a trust fund established for the benefit of specified residents and property owners. The royalty can be based on a per ton rate, adjusted perhaps according to the origin of the waste. Many possibilities exist for determining who is eligible for payments from the trust and the level of participation. A representative group of residents or a residents association may be appropriate to make those decisions. This responsibility can create conflict amongst residents and a defined formula approach may be preferred by local residents. The defined formula approach can work if the proponent has had extensive consultation with local residents and understands well the influence of landfill operations on different areas and properties around the landfill site. For one of our Canadian landfill projects, we devised a five group system with Group 1 sharing in the trust proceeds to the greatest degree and Group 5 to the lowest degree. For each Group specific properties were identified. The assignment of properties to specific Groups depended upon the presence of a number of factors:
    1. proximity to the landfill site (i.e. exposure to operational effects of the landfill);
    2. residential occupation of the property versus farming or other non-residential uses;
    3. adjacency to the different site access roads with different volumes of truck traffic;

4. ownership acquired subsequent to announcement of trust fund concept.

Group 1 residents were guaranteed a minimum payment of $5,000 per year. The weighting for Group 1 benefits for each resident was sixteen times the amount payable to each Group 5 resident. Approximately 250 residents were eligible in one of the five groups.

8. Property value protection

Property owners who will become neighbours to landfill sites frequently fear a loss in value of their property will result from the landfill presence. There is little evidence to support this general linkage. This may, in part, be due to market price determination for commercial farm land being based on commercial returns achievable based on crop yields, crop prices and interest rates. There is also some measure of land speculation bordering landfill sites in anticipation of future land requirements by the landfill operator. Whatever the reasons, it may serve to erase the sincere concerns of nearby landowners to offer some form of guarantee of protection against market value decline attributable to the landfill. There are, again, a number of ways of approaching this. One method is to have an appraised value established that is updated yearly. When a third party offer is received, the proponent may option the land at the appraised value or pay the vendor the shortfall. The vendor may sell to anyone at anytime without triggering the proponent's option rights but the option rights are triggered where the vendor seeks the property value protection. It should be noted that other benefits offered, such as royalties, may serve to support and increase property values in the area around the landfill site.

CONCLUSION

Addressing host community concerns and establishing a supportive host community relationship presents a considerable challenge to the landfill project proponent. The challenge will task your creativity and perseverance. Meeting the challenge successfully requires the preeminence and separation of environmental safety from other issues, the adoption of a genuine caring and emphatetic attitude to host community concerns, the use of a public consultation and mediation process that is open and has integrity and the resolution of benefits for the host community that are objectively fair, equitable and can be viewed broadly as being beneficial to the well being of the community. This will not immunize a proponent from detractors but it will enable a proponent to participate in the approval hearing from a position of strength. There are no magic cures - just dedication and commitment.

WASTE MANAGEMENT IN COTTAGE COUNTRY
A PUBLIC PERSPECTIVE

BY

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CO-CHAIR PUBLIC LIAISON COMMITTEE
COUNTY OF HALIBURTON

BACKGROUND

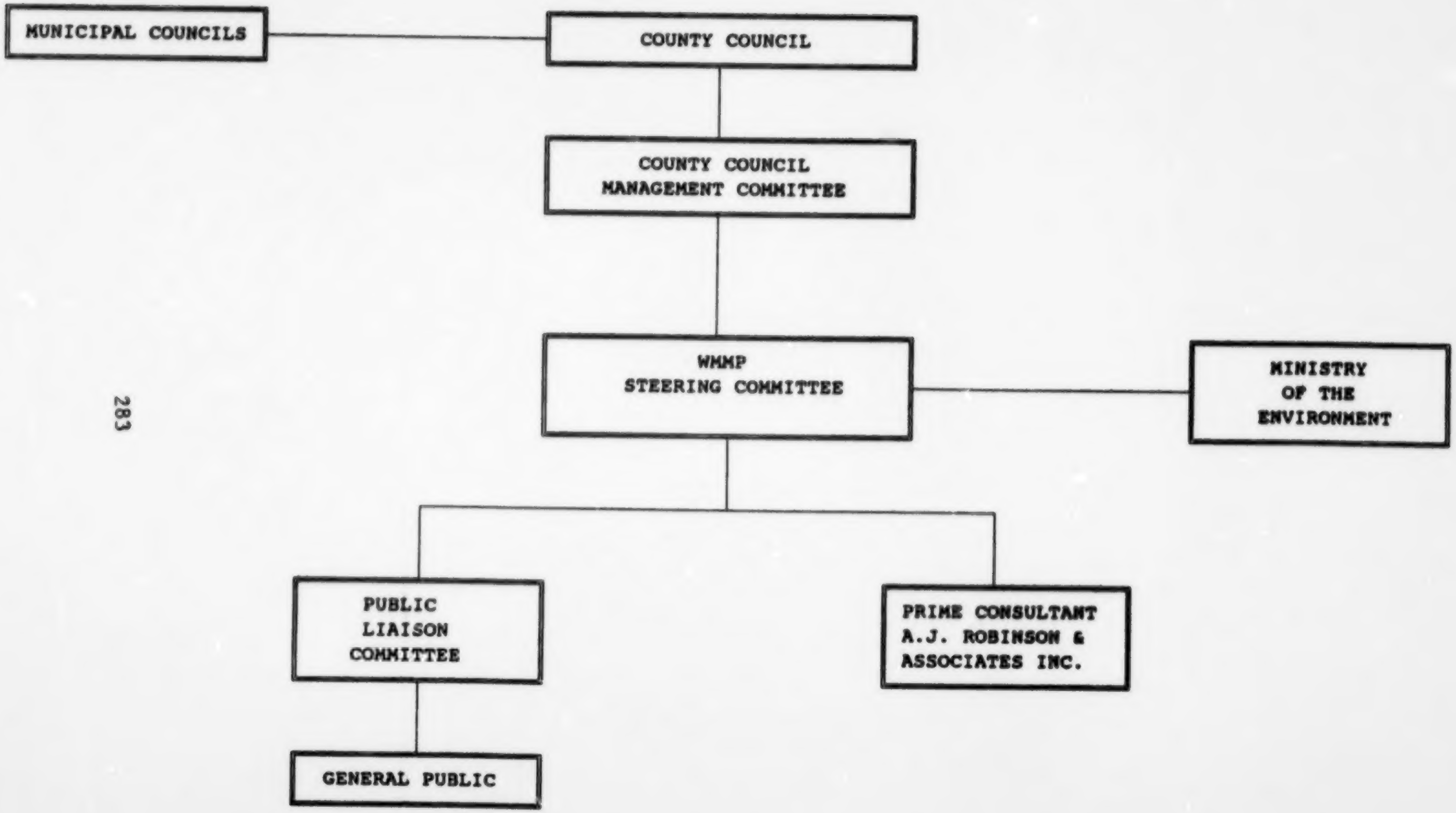
The County of Haliburton is located in central Ontario, east of Georgian Bay and south west of the Ottawa River. Part of the County lies within the boundaries of Algonguin Park. The area known as the Haliburton Highlands is noted for its scenic beauty and vacationing Located on the Canadian Shield, Haliburton is characterized by frequent rock outcrops, shallow overburden and numerous lakes.

The area of the County is approximately 4520 square kilometres. The permanent population of the County is approximately 12,000 people. However, due to its popularity as a vacation area, there are a large number of seasonal residents who live in seasonal homes or cottages. It is thought that cottagers may add 30,000 people to the permanent resident population. These seasonal residents are mainly present between May and October. This mix of permanent and seasonal residents presents interesting differences between solid waste management in Haliburton County as compared to many other areas of the Province of Ontario.

The County of Haliburton is comprised of 10 individual municipalities. These municipalities agreed to develop a Waste Management Master Plan to develop a strategy for solid waste disposal on a county-wide basis. A Steering Committee was formed consisting of the Reeves of the municipalities.

Haliburton County Municipalities

Municipalities	1988 Population	Households	Area (ha.)
Anson, Hindon & Minden	2683	2869	50916
Bicroft	618	309	3064
Cardiff	602	1197	24374
Dysart et al	3928	5547	150597
Glamorgan	534	1298	20621
Lutterworth	784	1465	17252
Monmouth	693	862	22362
Sherborne	430	1800	126647
Snowdon	725	747	20909
Stanhope	948	2115	15540
Total	11945	18209	452282


MUNICIPAL COUNCILS
COUNTY COUNCIL
COUNTY COUNCIL MANAGEMENT COMMITTEE
WMMP STEERING COMMITTEE
MINISTRY OF THE ENVIRONMENT
PUBLIC LIAISON COMMITTEE
PRIME CONSULTANT A.J. ROBINSON & ASSOCIATES INC.
GENERAL PUBLIC

THE WASTE MANAGEMENT MASTER PLAN STUDY

The Terms of Reference for the County of Haliburton Waste Management Master Plan were issued in January 1990. The Steering Committee selected a consulting engineering firm, A.J. Robinson & Associates Inc. to undertake the preparation of the Master Plan.

The organization chart for the Waste Management Master Plan process is typical for studies of this nature in Ontario.

The master plan process was divided into five stages.

The stages are as follows:

Stage 1

This stage involves the collection, review and documentation of data that establishes the need for waste management facilitates and the identification of feasible waste management options and components. Evaluation criteria which will be used to rank and weigh waste management systems will be developed.

Stage 2A

At this time, the preferred waste management system will be identified. Thus the need for example for a landfill site, would be clearly established and therefore the selection of a landfill site is not clouded by the issue of whether or not one is required.

Stage 2B2

The potential candidate areas will be examined to identify suitable landfill sites. A ranking system will be developed and utilized. Compensation issues will be addressed.

Stage 3A

The net environmental effects and mitigative requirements of the preferred system and sites will be considered. Implementation plans and cost sharing municipalities will be developed.

Stage 3B

This stage will see the preparation of an overall document to be submitted for acceptance/approval under the Environmental Assessment Act.

In the County of Haliburton at this time, we have completed Stage 1. Work has began on Stage 2A.

PUBLIC INVOLVEMENT

From the start, the County of Haliburton has been committed to public involvement in the waste management master plan. Unfortunately, the public at large is not necessarily committed to the waste management planning process.

In September 1990, the consultant held open houses at three locations throughout the County. The result was sparse attendance despite wide spread advertisements in the local papers.

This sparse attendance early in the study process is typical of waste management master plans. Garbage is not necessarily an exciting topic. Similar experiences have been noted in other cottage area municipalities near Haliburton. Unless a specific site or sites are identified, the general public does not appear to be anxious to get involved.

As early as 1989, the process of establishing the Public Liaison Committee began. However, the establishment of the Public Liaison Committee did not start in earnest until the fall of 1990. Advertisements and articles in the paper requested volunteers. The response was underwhelming.

The initial meeting of the Public Liaison Committee (PLC) was held on December 20, 1990. At that time, three of the ten municipalities had not identified volunteers for the PLC. One of these municipalities sent a councillor as a stand-in until a volunteer could be found. A teacher and student from the local high school were also on the PLC in an attempt to directly reach the young people.

Despite the large seasonal population in Haliburton County, only two seasonal residents were on the PLC. This was seen as being a potential problem by the committee. However, the seasonal residents viewpoint is always sought at the committee meeting. To date there has been excellent cooperation among all members of the PLC.

At the second PLC meeting in early January 1991, the chair and co-chair of the PLC were elected. I believe the committee made the right decision by electing one permanent resident and one seasonal resident to be chair and co-chair of the PLC. This allows a balanced view to be brought to the PLC and to the Steering Committee.

At the time the waste planning study began, each of the ten municipalities was responsible for its own solid waste management. There are 22 landfill sites owned by the municipalities along with 5 private landfill sites. There is no municipal solid waste collection. There are several private collection services that serve mainly commercial and industrial businesses.

As a result of having no collection systems, residents must take their waste to the local sanitary landfill site. This system does not seem to concern the local residents as I have never heard about a request for a public collection service. I can tell you that cottagers are not in favour of a public collection system. Cottagers generally return to their permanent homes on Sunday afternoon or evening. If their solid waste was set out at that time and if collection was not until Tuesday or Wednesday, the waste would be strewn all over the county due to the large amount of wildlife in this area. A municipality operated solid waste collection system would be counter-productive to the promotion of public health and the prevention of litter.

Recycling was initially undertaken by three of the ten municipalities. These recycling programs generally consisted of the municipality contracting with a private company who in turn places a large roll-off compartmentalized dumpster at the landfill site. The materials are separated by the residents into newspapers, glass - both clear and coloured and cans.

Many people have complained about the recycling program. Their complaints began with - why don't we have a recycling program? Those who did have a recycling program said that it did not work properly.

The PLC meeting in December and February were mainly taken up with procedural issues and for the members to develop an understanding of the waste management master planning process. The public were invited to our PLC meetings but these early meetings did not have many of the general public attending.

We decided to have an open house in March during which the consultant would make a presentation of the waste management planning process. We were aware of the difficulty studies of this nature have in getting people to attend during the early stages. We thus undertook a vigorous public notification program. Methods used included:

- production and distribution of flyers
- advertising in the four local papers for two consecutive weeks
- article presented in the local papers
- personal phone calls.

Our advertising campaign cost the PLC $535. The resultant attendance was 35 including 6 members of PLC, 2 members of the Steering Committee and 3 members of the press. Thus the general public who attended was approximately 24.

It was at this time that we ran into our first problem. We had spent $535 on advertising and $5,000 on consultant's fees only to reach 24 people. This was viewed as a major disappointment. Several articles in the local papers referred to the cost involved in putting on the public meeting and the relatively poor attendance. Upon discussing the matter with others, it became clear that in many areas the public only want to be involved if you are going to discuss specific sites. This appears to be an unfortunate general rule.

Another embarrassment was the fact that the daily charge-out rate for the consultant was published in the papers. In an area where many people work for minimum wages, people get upset when they hear that the consultant is charging approximately $100 per hour.

However, despite the disappointing turnout, the consultant made a good presentation concerning the study process and those present made good points and raised key issues.

One gentlemen made an excellent point concerning any waste management system. Any system should be easy to use, user friendly, effective and let the user know that he or she is actually making a contribution to cleaning the environment.

Poor examples of recycling can be found in Haliburton County. For example, people leaving plastic bags full of cans inside the can recycling bins. Poor sorting of all materials to be recycled is common. Another poor example is recycling bins that become full and are not hauled away. Therefore, cans are strewn on the ground around the compartment. These experiences can be depressing and must be eliminated in systems which require that people must bring the solid waste itself to the landfill/recycling site. It is very disappointing to work at separating the recyclable material and then encounter recycling bins that are overflowing and spilling onto the ground. People must be reassured that if they take the time to separate and to return for recycling that it is in fact being done.

In a parallel move, the County asked the consultant to prepare a recycling program for the County. This report was received in final form in July 1991. The recycling report recommended that the County develop a recycling program based on:

1. Single Recycling Containers.
2. Backyard Compostors.

This program is expected to have the County reach the stated Provincial goal of a 25 percent diversion of waste by 1992 and a 50 percent diversion by the year 2000.

The PLC is very supportive of the recycling initiative, however there are many issues that need to be resolved.

It was recommended by the consultant that a single container recycling box would be the best for the County of Haliburton. The single container, the ubiquitous "Blue Box" was identified as being cost effective and flexible enough to fit into almost any country-wide waste management master plan. The Blue Box is widely used throughout Ontario as an integral part of the recycling program. The Blue Box program has been so successful that I have heard that several of the County politicians felt that the County must surely have their Blue Box as well.

Haliburton County is not the typical Ontario County or municipality in which Blue Boxes have been such a success. Haliburton County remember has no municipal solid waste collection. This is a big difference.

In urban municipalities with solid waste collection, residents only have to put their recyclable waste into the Blue Box and carry it out to the end of the driveway once a week. Sorting is left to the municipal employee who picks up the Blue Box and sorts the contents into the proper containers in the compartmentalized collection truck. In Haliburton, the County will rely upon the resident to identify the recyclable material, place it into a Blue Box, transport the Blue Box to the landfill site along with other waste, then further into the various recyclable materials within the Blue Box and place into the compartmentalized container at the landfill site, and finally take the Blue Box home to repeat the cycle. All of this must happen in a part of Ontario that still has hot summers with flies and cold winters. Many questions about the success of a Blue Box program where there is no collection remain.

The first question is what value is the Blue Box itself. Many residents combine a trip to the landfill site with a trip to the grocery store or some other function. Thus one is faced with keeping the empty Blue Box in the car until the return trip, taking up space in the cars that are made smaller every year. Used Blue Boxes can develop a noticeable odour, particularly as they ferment in a car trunk on a hot day. Under these circumstances, separating the recyclable material into a deeper container rather than a Blue Box may be more appealing.

One more Blue Box issue is the requirement for residents to further sort the recyclable material at the landfill site. This is not always considered an enjoyable task. This task must be done in all kinds of weather and insect conditions. It would be considerably easier if the resident only had to separate the material once - at home. This could be done if residents were provided with multi-boxes. Each box would be for a specific recyclable material. Not all boxes would be filled at the same rate. When a box gets full, then that box could be taken to the landfill site and easily be emptied into the appropriate container without further sorting.

The Blue Box as we currently know it does not easily permit a multi-box approach. The PLC think that in order for a single Blue Box to be truly flexible, it must be easily expandable into a multi-box program. The criteria for a Blue Box to meet these objectives would be as follows:

- it must be stackable to allow loading of each box without taking up valuable floor space.
- it must be easy loading.
- it must be nestible to allow for reduced shipping costs and reduced trunk space requirements if the resident combines a trip to the recycling area with another shopping trip.
- it must be solid enough to retain particles of broken glass.
- it must be porous enough for materials storage without collecting water.
- it must be big enough to hold a newspaper folded flat.
- it must be durable.
- it must be made from recycled material.
- it must be economical to purchase.
- the colour need not necessarily be blue.

To my knowledge a box blue or otherwise meeting these requirements does not exist. On behalf of the PLC in the County of Haliburton, we challenge the manufacturers of Blue Boxes to come up with the second generation Blue Box - the Haliburton Hauler.

Compostors - this is another sacred cow we are examining in Halibutron. There are clearly two types of units available on the market - compostors and digesters. Each have their advantages and disadvantages. I do believe that some people have taken their eyes off the ball. The goal of their backyard composter is to reduce the amount of waste that goes to landfill sites. The goal is not to create compost! Compost is a benefit not the goal. Digesters do not seem to have been promoted well. The PLC has had difficulty determining if digesters or compostors are better for the environment.

In order to understand my point, again remember that in Haliburton we have no collection. In urban areas with collection a so-called garbage truck picks up the "garbage" at least once per week, A trunk will stop at the end of the driveway to pick up what the resident has put out. Rain or shine. Summer or winter. Thus putting the permitted material into a compostor by an urban resident does not restrict him or here from disposing of the non-permitted food wastes with the regular waste disposal.

In areas where there is no collection, residents must go to the landfill site when their containers are full or when they can no longer stand the smell. Remember that going to the landfill site is not necessarily the most desirable trip in the world. As I have often said - it's too bad sanitary landfill sites have to look like dumps! Thus a reduction in the number of trips to the sanitary landfill site is desirable both to the resident and the operator of the landfill site. This can best be achieved with units that are digesters. Digesters can accept many types of food wastes that compostors can not accept. A digester rather than a compostor could reduce the number of trips to the landfill site based on smell and to a lessor extent based on volume.

Digesters however, do not produce compost, Almost every document on recycling emphasizes composting., People feel that they will be good citizens if they produce compost for their gardens. While this is to be commended, reducing the waste that reaches the landfill site is the goal of the County. We would like more information as to the environmental performance of compostors versus digesters.

While I think digesters are an effective solution to handling organic wastes, their use in cottages is not without difficulty. There is a great deal of wildlife in Haliburton County. Racoons, skunks and bears can all be very determined. Digesters must be designed to be as animal proof as possible.

The matter of cost sharing and subsidy for Blue Box an backyard compostors/digesters has led to some confusion on my part. Where I normally live the Blue Box was provided to our household without asking for a direct payment. I have a compostor in my backyard that I bought at my choice from the Town at a cost of $25.00.

In the County of Haliburton, both single container recycling box and backyard compostors/digesters were identified as being the major components of a recycling program. The method of payment or cost of each of these items has not been established at this time. In my opinion, however, the approach must be consistent either both of theses items are provided free of direct cost to the household or a fee is charged for both.

These are some of the issues that we have to deal with in Haliburton County.

I wish to thank Ms. Bernie Davis, Chair of the Haliburton County Public Liaison Committee, Mr. Len Munt former Waste Management Co-ordinator and Mr. Paul Frigon of A.J. Robinson & Associates for their assistance both on the PLC and the preparation of this brief.

"IMPACT OF NEW SOLID WASTE REGULATIONS ON SMALL COMMUNITIES"

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Introduction

With the advent of new solid waste regulations that are both restrictive and demanding, small communities are entering a new era of costly ownership of solid waste. In the past, these communities, for the most part, have considered the solid waste problem as one of the easiest to solve. Collection was typically handled with a minimal number of collection vehicles or by the local trucking company, if curbside collection was offered, or by direct haul to the disposal site by the citizens of the community. Disposal was often accomplished by the trench method. The trench method involved excavation of a trench, the depth of which varied, into which solid waste was deposited. The solid waste was either covered, or in an effort to control volume, burned in place. When a trench was filled, a new trench was excavated and the process continued.

In many areas, these disposal facilities were located in river bottoms or other areas where the usefulness of the property was limited. This disposal system has improved since the 1960s. During the late sixties and first half of the seventies, the first regulations regarding solid waste were implemented. Control of blowing debris, burning of solid waste and flooding of the disposal site were the key elements of these regulations. Disposal sites were gradually moved out of flood-prone areas and into areas with deep ravines or similar topographics.

Project Status

Small communities, communities with populations of 10,000 or less, make up over 60 percent of the communities in the United States. These small communities are most directly affected by the new solid waste regulations.

Most communities are diligently addressing solid waste, but with limited funds and increasing liability, these efforts are seldom successful. Most disposal facilities are susceptible to flooding, groundwater contamination, air pollution and fires. More importantly, a number of these communities have limited ability to properly monitor the inflow of solid waste and subsequently wastes that are harmful to the environment can find their way into these landfills. Examples of these problems include the disposal of large quantities of hazardous waste in county-owned landfills, hazardous materials discovered in municipal landfills, contaminated groundwater near or under landfills and identification of landfills as superfund sites.

Regulations

The United States Environmental Protection Agency (EPA) has developed new solid waste regulations under Subtitle D of the Resource Conservation and Recovery Act. These regulations are intended to address the deficiencies of previous regulations and to further protect the environment. The regulations have been modified by various agencies during the past four years to reflect the impact any regulation would have on the constituency.

In response to these new regulations, states have put into place or will soon have in place, new solid waste regulations that meet or exceed the EPA regulations. These state regulations emphasize environmental protection in conjunction with proper operation and financial responsibility of solid waste systems. Other highlights of the regulations include waste reduction and recycling goals, collection and transfer requirements, and closure-post closure responsibilities.

Local governments have also developed solid waste regulations. These regulations are in response to the closure of smaller disposal facilities and the desire of these communities to transfer solid waste to other facilities. Most local regulations are being developed, or are in place, in large communities. This local regulation approach allows these communities the opportunity to control the inflow and subsequent responsibility for solid waste.

Given the regulations climate, small communities have found it very difficult to plan for solid waste. This lack of planning has resulted in a number of smaller communities taking a "wait-and-see" attitude toward the new regulations.

Regulation Impact

There is no single group that is more directly impacted by the new solid waste regulations than smaller communities. The regulations have burdened smaller communities with more responsibility and more liability with no additional financial support. The greatest impact will be felt in the areas of collection, transportation, disposal, operation and closure-post closure responsibilities.

The impact on collection will be two-fold. First is access. With new restrictions on the operation of disposal facilities and subsequent increased liability, it will be much more difficult for local citizens to simply visit the landfill. The second impact is procedure. With aggressive waste reduction goals, collecting solid waste will become more compartmentalized. Yard waste and other compostable material will be segregated; curbside recycling may be instituted; disposal materials may not contain any hazardous wastes. Given these restrictions, small communities will have to consider expanded services and the required capital expenditures to supply these services. In addition, larger facilities, new and different equipment, and manpower changes must also be considered in this process.

The transportation of solid waste could also be seriously impacted by the new regulations. Although the EPA regulations do not specifically address the transportation of solid waste, a number of state and almost all local regulations do. State regulations are written to consider districting as a cost-effective way to control solid waste. The districting concept includes provisions for controlling and charging for solid waste transported over preset district boundaries. Local regulations have gone even further. These regulations identify surcharges on waste, limits on the amount and type of waste, or the complete ban of imported waste. These numerous restrictions have left many smaller communities in a "Have or Have-Not" environment. The "Haves" are those with facilities that will take solid waste with limited financial impact. The "Have-Nots" are those seeking such facilities. The "Have Nots" outnumber the "Haves" by over 50 to 1.

The greatest impact of these new regulations is in the area of disposal. Disposal of solid waste has always been a problem but with the new regulations, disposal has also become very expensive. Smaller communities often find themselves with sites that are not permittable under the new regulations. To obtain a permit for the disposal site often involves extensive efforts and an even greater amount of documentation. Smaller communities find this to be extremely difficult and frustrating. The result is often no response to these regulations and a defiant position by the community. The other response is smaller communities attempting to join together to form solid waste authorities or regions. Often, the major problem communities experience with regionalization is a lack of trust between communities necessary to make such unions work.

Facility operation is being impacted significantly by the new regulations. Daily cover, fire control, accessibility to water, control of materials deposited at the site, groundwater monitoring, drainage control and surface pollution control are all required by the new regulations. These new requirements add staff and equipment. In addition, the flow of solid waste into the facility must be monitored and placement must be documented. Finally, consideration at both the federal and state level of operator certification would seriously impact communities' ability to financially afford to operate a facility.

Another major concern of smaller communities is long-term responsibility. With the almost routine discovery of hazardous waste in solid waste landfills, smaller communities are more concerned than ever with the potential responsibility for the cleanup of sites. These long-term responsibilities also carryover into the small communities ability to identify sites for disposal. Many small communities have often leased land from federal or state agencies for use as a landfill. This procedure has allowed small communities the opportunity to utilize inexpensive land for disposal. However, with new liability requirements for landowners, this arrangement is in jeopardy. With the loss of this land for disposal, small communities are faced with higher costs and limited site availability.

Impedance

Small communities, like all communities, must meet the new solid waste regulations. However, their efforts have met with, and will continue to meet with, impedance from three areas: local citizens, costs and regulations.

Local citizens are often not highly motivated with respect to change. And with solid waste, change is even less acceptable. In many communities, the view of the local citizens is that the disposal of solid waste is a right and should not be tampered with. The disposal of solid waste, to most citizens, is considered simple and inexpensive. To find a disposal site is as easy as identifying an open ravine.

These attitudes impede the efforts of small communities to meet the new regulations. The effort to educate the citizens of a community regarding the impact of new solid waste regulations and associated costs of these regulations is very challenging and frustrating. However, without the acceptance of the citizens of a community, success in meeting the new regulations could be impossible.

As with any aspect of local government, costs associated with meeting the new regulations will have a major impedance to the implementation of those regulations. New solid waste regulations from federal and state governments do not include a revenue source to allow communities the opportunity to meet these regulations.

Without financial support from other governments, the smaller communities must generate funds from the local citizens. Typically, the costs associated with meeting the new regulations will vary from an increase of three times present costs to over ten times present costs. To meet these additional costs, local communities must consider raising fees to the citizens directly or through other tax sources. This approach has met with limited acceptance by local citizens. As noted previously, the local citizens need to be educated on the impact of the regulations as well as the related costs of these regulations. Even with an effort to educate the citizens of a community, the ability to generate adequate funds continues to be a serious impedance to successfully meeting the requirements of the new regulations.

The third impedance is the regulations themselves. As noted, the regulations offer no funding for small communities but do present a specific schedule for permitting, waste reduction, closure-post closure requirements and operations. There is no allowance for delays in meeting the schedule set out in the regulations. This position has forced many small communities to pursue changes to the regulations through legislation or by lobbying the regulators for change or delay. This approach has been successful in only delaying the regulations and allowing regulators the opportunity to expand the solid waste regulations.

Solutions

There are a number of potential solutions to the present problem of the impact of new solid waste regulations on small communities. These include regionalization, consolidation, privatization, and postponement.

Regionalization allows small communities to join with other communities, both large and small, in addressing solid waste. Regionalization is based on the volume of waste and the area to be served. The important elements of regionalization for small communities are that costs are typically shared among a number of government entities; the overall size of the region allows for ease in meeting waste reduction requirements; equipment and knowledge can easily be shared. The disadvantages of regionalization are the lack of mutual trust among communities and the siting of disposal facilities near small communities to appease larger communities.

Smaller communities have already begun utilizing the concept of consolidation. Consolidation involves bringing together more than one community to operate a solid waste system. In a number of areas, smaller communities have found that by consolidating their systems they save money and share liabilities. The disadvantage to consolidation is the dependance of communities on each other. Unlike regionalization, consolidation usually involves communities of similar size and concerns. These similarities also work against the success of consolidation as the available funds and technical resources are limited.

Another solution to addressing the regulation problem is through privatization. A number of small communities have turned to private companies to address the communities' solid waste. The disadvantage to privatization is the continued responsibility communities have for their solid waste and the potential cost increases to the citizens of the communities.

With the new regulations, the generator of the waste retains responsibility for the waste. Because of this added responsibility, small communities cannot simply turn the solid waste program over to a private firm without community staff to monitor the firm's efforts. Potential cost increases to a small community may occur due to poor contract negotiations with the private firm. Small communities need to have detailed contracts that control both rate increases and also proper collection and operation procedures.

A solution some small communities have utilized is the concept of postponement. These communities believe that by ignoring the regulations and postponing the implementation of any requirements of the regulations, this will allow the community time to generate funds and citizen support to meet the regulations. Or, the other plan is to ignore the regulations and leave the responsibility of the regulations to the regulators. The disadvantage to this option is that regulators also have the authority to fine communities that are not in compliance. Even if the regulators move to correct the solid waste situation, the community may still be fined and assessed for failure to comply.

Other solutions to the regulations include legislative action to modify the regulations or to generate funding; developing a solid waste authority that would identify methods to collect, dispose and monitor the solid waste; and where possible, annexation with other communities to increase the tax base and share liabilities.

Closing Comments

The driving force behind any regulation is the protection of the public and for the better good of the public. The new solid waste regulations are designed to accomplish this task. For small communities, the largest single group impacted by the regulations, these regulations will be difficult to implement without the necessary assistance that has been common with water and wastewater regulations. To ensure the solid waste regulations meet the forces that have driven them, financial support to small communities must be made available.

Rural Action on Garbage and the Environment

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On a chill Spring evening in 1989, we met at a neighbour's house, most of us anxious about the rumour that Toronto city garbage would be exported to our rural community. Armed with only newspaper stories and local reports, we sat around the kitchen table, trying to piece together the situation and speculating on a course of action. Each of us, men and women from nearby farms, homemakers, shop-keepers from the nearby villages, truck drivers, and retired folks were determined to organize a citizens' group to investigate and oppose the exporting of Toronto area garbage to rural Ontario.

That meeting in March of 1989, was the first of many held in farm kitchens, living rooms, and community halls around the province. Eventually, those citizens' groups connected with me and citizen activist John Jackson of Kitchener, Ontario, to form RAGE, Rural Action on Garbage and the Environment, a coalition that represented citizens from the Southwest, Central, and Northern regions of the province.

Our purpose was simple: stop the Greater Toronto Area (GTA) from exporting millions of tons of city garbage to the Ontario countryside for landfill sites or Energy From Waste (EFW) incinerators. This large urban region which produces some 4.5 million tonnes of waste annually had run out of landfill space, more accurately political space in which to dump their garbage. For the next two years, RAGE member groups distributed information, held public meetings, planned citizens' action, lobbied local and provincial governments, and politicized rural Ontario on the fundamental issues of regional equity and responsible waste management. We initially responded only to the issue of export, but we soon realized that a constructive and credible campaign would have to include alternatives to landfill disposal and EFW facilities, alternatives that would reduce our consumption, conserve our resources, and protect the integrity of our communities.

While the GTA garbage crisis initially threw us into confusion, it became the single, most unifying force to revolutionize how rural Ontario citizens now approach the issue of waste management. Alerted to the political, economic, and social complexities of garbage, we've learned critical lessons about the inequities of urban and rural responsibilities and the need to defend our local interests. Therefore, to understand our current waste management issues, we must first examine how the Toronto garbage crisis enlightened rural Ontario.

Our opposition was not simply the NIMBY, "not-in-my-backyard", reaction to garbage, but rather a response to the larger issue of social justice. These proposed mega-projects overwhelmed the resources and infra-structure of our small rural communities and exceeded available community services: roads, access routes, and leachate treatment facilities. One company, for example, proposed hauling 3,300 tonnes per day of Toronto area garbage to Lambton County for EFW incineration, to burn for 20 years. In comparison, the entire of County of Lambton produces only 300 tonnes of garbage per day. In fact, the bottom ash from this one EFW would have filled all the county landfills and more. In another rural area, Laidlaw Waste Systems proposed a 200 acre site, 2,000 tpd, waste piled 110 feet high; in comparison, the village water tower across the field is only 105 feet high.

Our opposition focussed as well on the critical issue of responsible waste management. Exporting waste over several hundred miles displaces the immediate responsibility of garbage - "Out of sight, Out of mind" - by allowing one prosperous community to export an unattractive crisis to a less prosperous, remote community that buys into a garbage economy, making itself dependent upon society's wastefulness. In one instance, an economically depressed community in Northern Ontario was reputedly a "willing host", but many GTA citizens objected strongly to a plan that would very likely damage a fragile ecosystem. Furthermore such a plan would deny them their right to take progressive environmental action on waste management within their own GTA region. For them, the concept of exporting waste contradicted their own commitment to social equity and justice.

In our view, exporting garbage erodes the integrity of both communities, unfairly shifts the balance of accountability, and establishes two social classes: the affluent who export and the poor who dispose of the garbage. But by developing and implementing effective programmes, large urban centres can be accountable and, in the end, benefit themselves along with the rest of society.

During the GTA garbage crisis, rural communities confronted national waste companies such as Browning Ferris, Laidlaw Waste Systems, and Ogden Martin, international companies proposing expanded landfill sites, new sites, Energy From Waste facilities, proposals described as employment and development opportunities. In fact, speculation on garbage as a growth industry became so rampant that soon small investors and local operators optioned hundreds of acres of Ontario farmland and wetland as possible disposal sites. And to gain local support for their mega-projects, these developers wooed municipal politicians with promises of free disposal and an increased tax base. Platoons of corporate consultants, engineers, and marketing experts marched across rural Ontario, prepared to offer compensation and negotiate long-term deals with municipal councils and minimize our local opposition.

This frantic search for disposal sites caused companies to misread the text of rural community life and conflict arose from a fundamental misunderstanding of two very different societies. From the city came urban consultants and proponents who viewed our farmland as "remote," "vacant," "unused" property, the ideal solution for Toronto's garbage crisis with considerable profits for private companies. Their vocabulary consisted of words such as "potential," "access," "mitigate," and "consult". Meanwhile we considered these urban speculators threats to our community, exporting an urban crisis to our rural communities.

An incident involving local residents and Laidlaw Waste Systems illustrates these conflicting attitudes. When Laidlaw Waste Systems unveiled its expansion plan for Warwick Landfill, Lambton County, large, colourful maps detailed various access routes to the proposed area. As Laidlaw's traffic consultants tried to assure us that they recognized our concerns, one local couple realized that one of Laidlaw's access routes passed through their farm, in fact, directly through their kitchen. When the young couple objected, the consultant said the company would simply buy their property and they could re-build somewhere else. "But," said, the young man, "we've just papered the kitchen!" The consultant had already moved onto other issues.

Much of the garbage debate really centred on how we, as a society, would manage our waste. Would we continue to fill huge holes with garbage and burn it as energy as many of the proponents advocated, or would we revolutionize the entire process by emphasizing conservation of all resources? Proponents for disposal sites, naturally, argued that while some garbage could be diverted, vast quantities of waste would still have to be landfilled or incinerated at sites scattered throughout rural Ontario. As we were told so often, "It has to go somewhere." Yet "somewhere" was never in or near the urban centre which generated the waste, and proponents themselves lived far away from their "state-of the-art-facilities". RAGE members countered that those who created the problem must solve the problem with each region and municipality accepting responsibility for its own waste, in particular, reduction and disposal strategies.

These conflicting approaches to the issue of waste management gave rise to the proverbial call of "NIMBY" and an escalation of conflict. In the summer of 1990, Ogden Martin sales representatives held a public information meeting in Lambton County to promote their Energy from Waste incinerator facility that would burn some 3,300 tons of Toronto area waste. In addition to their overwhelming opposition to accepting GTA waste, many citizens expressed concern about the environmental and health affects of the EFW. One after another, local men and women challenged the Ogden Martin marketing representative who, in complete frustration with the public consultation process, finally called one local resident "NIMBY," saying, "We see your kind all the time when we visit communities." The audience was astonished that a stranger from Toronto would have the impertinence to challenge the integrity of a long-time resident. When face to face with public opposition, the company displayed little understanding of the community's social and cultural values. Perhaps no other statement affected citizens as much as the NIMBY accusation, an epithet that we've come to respect as a declaration of citizens' action. In the weeks following, hundreds of local people opposed the EFW facility, and eventually Moore Township Council unanimously rejected Ogden Martin's proposal.

Perhaps, we can take a moment to reconsider "NIMBY," the term commonly used to discredit someone interested only in personal property, someone considered un-enlightened, as if the motivation to preserve one's territory were somehow abnormal. I would suggest that each of us here would instantly become a NIMBY if his or her home, personal property, or neighbourhood were threatened. Urban residents often live in safely established neighbourhoods that will not be considered for landfill sites or incinerators or sewage sludge disposal; I understand why NIMBY seems far removed from their experience. But in rural Ontario, NIMBY is real and legitimate, and a more complete and current definition includes a broader population affected by the principles or ideas of a proposal. Social movements for change - environmental, political, or cultural - quite logically begin with self-interest and mature into enlightened self-interest that benefits the entire community and indeed society.

RAGE group members worked for well over a year against the GTA proposal, lobbying local and provincial governments, until finally, in April of 1990, the newly elected Ontario NDP government kept its promise to prohibit garbage export and made the Greater Toronto Area responsible for its own municipal solid waste. Furthermore, Environment Minister Ruth Grier banned incineration of municipal solid waste and EFWs, making conservation and waste reduction the mandate for local and provincial government. The original members of RAGE have moved onto other issues: working to re-claim those proposed landfill sites as recreational areas and farmland, protecting wetlands as environmentally sensitive areas, and implementing local waste reduction plans. The Toronto garbage crisis alerted country people to the whole nasty business of garbage, not only Toronto's, but our own as well, and with this "Greening" of rural Ontario, we're no longer waiting for government agencies to initiate programmes. We're taking steps ourselves through the Waste Management Master Plan to improve our local waste systems.

Rural citizens groups now face private garbage disposal companies that want to expand existing sites to serve the entire province or regions including five to ten counties. But again, these proponents often neglect the basic concepts of responsibility and equity, continuing to believe that with just the right strategy, an attractive compensation package, and technical reports, we will accept their proposals. They're mistaken.

We've learned a great deal about the dynamics of the garbage disposal business, in particular, that private waste management companies often follow their own agenda of financial and corporate growth, whereas citizen's groups follow an agenda of community sustainability. And the two agendas have little in common.

Misconceptions persist about rural communities, misconceptions that escalate the conflict corporations and rural citizens. In the WasteTech '91 and the Canadian Waste Management Conference (CWMC) programme brochure, for example, we read that managing waste will bring "regional opportunities" to areas outside the cities, yet in our experience those "opportunities" often exploit communities, ignoring important social and cultural implications. And some presentations, in particular, "Host Community Relations in Rural Communities" by Browning Ferris and "Not in My Backyard: Successful Siting of Solid Waste Disposal Facilities" by Chambers Development Company promise to solve the difficult problems associated with siting facilities in hostile communities. But garbage companies miss the point when they continue to discuss waste management with terms such as "opportunities," "host communities," and "NIMBY," terms which illustrate the ideological conflicts between private proponents and the residents of rural communities. And as long as they ignore the fundamental principles of responsible waste management and place corporate interests before community values, they will face growing opposition from citizens' groups who advocate a public system accountable to local interests and local objectives.

Across Ontario, municipalities have already experienced the escalating costs and economic monopolies of private garbage disposal contracts, and taxpayers and politicians are now promoting public systems for waste management with a limited and controlled relationship with private industry. RAGE believes that when municipalities manage garbage disposal, reduction and re-use strategies, Blue Box, and composting programmes, citizens benefit financially and environmentally while freeing themselves from the profit margins and the expansion plans of garbage companies. Landfill capacity for some residual waste will, of course, be required, but only after communities have met serious reduction standards and truly minimized the need for waste disposal. Our experience indicates clearly that a public system of comprehensive waste management, not an exclusively private system, works in the best interests of conservation and the community

Private disposal companies may argue greater cost efficiency, but they must recover their costs and earn profits for shareholders. Private firms must collect millions of public dollars to recover their investments and profit from tipping fees while giving secondary attention to waste diversion programmes. Private disposal contractors consider garbage a growth industry and often have little real interest in reducing the volume of waste going to their landfills because they're paid by the load: the more we throw away, the more they profit. Because the interests of private waste management companies can often work at cross purposes to the public interests of reduction and diversion, citizens need to scrutinize private operations carefully. Allow me to illustrate.

When Philip Environmental bought Petrolia's municipal landfill for $300,000 in October 1990, the company imposed three possible conditions guaranteeing profits: if the site proves profitable, if the province allows non-hazardous commercial-industrial waste from across the province (or a regional area of five counties), and if Petrolia Council supports the proposed site expansion, the town will get $20 per ton and split the profits. While the town agreed to these conditions, its interests appear to be tertiary compared to those of Philip Environmental. And the larger reality is that local residents will live with this rural landfill site for decades to come, and any short-term economic gain may well pale compared to the long-term liabilities.

Ten years ago, the City of Kingston privatized collection and disposal expecting to save taxpayers money. Kingston's waste was handled at Laidlaw's Storrington site under a 1987 agreement for $25 per tonne, due to expire in 1995. But Laidlaw cancelled the city's contract in March of this year. During the protracted legal battle, Kingston Ald. Mary Fleming described Laidlaw as "an uncontrolled monopoly that has us over a barrel... Our options are really limited by the fact that Laidlaw has cornered the market in this area. They own the transfer station, and they own the dump." Without options, Kingston taxpayers now pay Laidlaw $120.00 per tonne to haul city garbage to Laidlaw's Ottawa-Carleton site. In our view, tipping fees should reflect the true costs of waste management and be realistic incentives to reduction, but fees should be established in a public system, not the private sector.

Meanwhile private disposal sites around the province threaten to disrupt rural communities. In Kent County, Browning Ferris Industries plans to expand their landfill site and the service area of Ridge Landfill to include the entire province. In Lambton County, Laidlaw Waste Systems has applied to increase their site operation: twice the acreage for a province-wide certificate at ten times the current daily tonnage. Both these companies consider garbage a growth industry and the potential for profits endless if only then can expand their facilities and market place.

These situations illustrate the fundamental conflicts between private disposal companies that support an ever-expanding market and the public who consider waste management another public utility. Many of us who have lived with the presence and track record of private waste disposal companies no longer trust companies such as BFI, Laidlaw, Philip, and smaller operators to represent our local interests and protect the environment. We oppose landfill and incineration projects for province-wide disposal of MSW or ICI waste, as well as long-term expansions of rural landfill sites. In our view, waste management must be locally based, fulfilling the objectives of our community through relevant education and reduction programmes, positive incentives such as user pay, hazardous waste reduction and disposal programmes. Greenfield sites will reflect the community criteria with composting and recycling facilities.

Of particular importance are the progressive initiatives of the Ontario Environment Ministry to establish waste reduction measures and effective programmes for diversion, measures strongly endorse these measures as the long-awaited and move all us If private companies believe they can contribute to this public plan, we welcome their participation, but only if they acknowledge our public agenda for community accountability.

RAGE members are now organized around Waste Management Master Plans that advocate publicly owned and operated systems accountable to elected officials rather than the special interests of private waste companies. The citizens of rural Ontario believe that if each region and county provides a public waste management plan with serious waste reduction measures we can solve the garbage crisis.

One lesson in particular remains relevant: ordinary citizens can organize themselves to present coherent and persuasive arguments of social justice and environmental responsibility. We learned that by working together through local groups and then by organizing a provincial coalition, we can succeed. And each time a small group of rural citizens meets around a kitchen table to discuss garbage, the issue of waste management will be the issue of preserving rural life and the rural community.

ECONOMICS AND SOCIAL ASPECTS OF WASTE MANAGEMENT:

A REGIONAL APPROACH TO COLLECTION AND DISPOSAL IN NORTH DAKOTA

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ABSTRACT

This paper evaluates the current structure of municipal solid waste (MSW) collection and disposal in North Dakota. It evaluates the location of existing landfills and the general pattern of waste hauling for the existing landfill system. The paper also reviews recent legislative initiatives in North Dakota which have set up planning districts to formulate comprehensive waste management plans for the state. The paper also recognizes proposed solid waste rules which were released in draft form in September, 1991 by the State of North Dakota.

Collection in low population density rural areas and small communities necessitates transporting wastes greater distances to disposal facilities than was common in the past. In order to provide enough volume for a landfill facility to economically operate, the owner must secure wastes from a larger geographical area.

The paper attempts to lay out logical service areas based upon existing landfills which serve the majority of the residents of North Dakota.

BACKGROUND

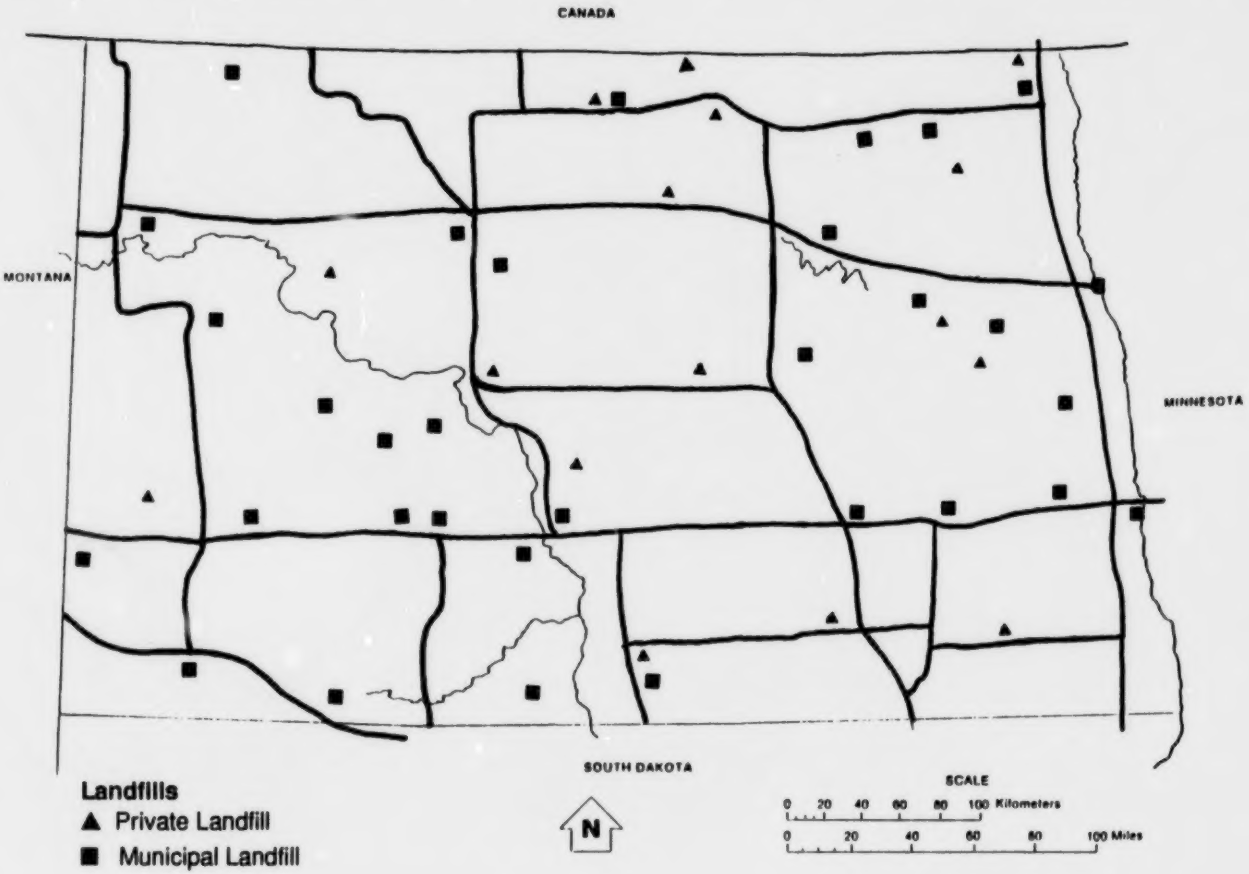
In 1989 the North Dakota State Department of Health (NDSDH) and Consolidated Laboratories listed 96 landfills as having permits for municipal solid waste. By 1991 the number had dropped to 49. The sites ranged in size from facilities serving the state's largest city, Fargo, to facilities serving incorporated areas of 100 people. The service area of the landfills in terms of geographic area is very great. Figure 1 shows the geographic dispersion of the landfills.

In February, 1991 the number of privately owned landfills was 16. Many of these landfills are extremely small and serve very limited geographic areas. The 33 municipally owned landfills serve anywhere from the community in which it is located, to an entire county. The state has 120 licensed waste haulers engaged in the collection and transportation of MSW. Several of the haulers are involved with the interstate shipment of MSW into North Dakota. There also may be a minor amount of export of MSW into adjacent states.

The principle landfills, except for the three largest private landfills, are located in the major cities of the state. The vast majority of the permitted sites serve very low populations.

The NDSDH grants a permit based upon acreage at a facility. Within that permitted acreage, the owner, whether private or municipal, may construct a facility that meets their service needs. Design, based upon volume factors, has been limited to a few facilities in the state. The issue of where waste originates has become more important in the permitting process than it was in the past. This is due primarily to the issue of interstate transport of wastes and the allegation by environmental groups that North Dakota will become a dumping ground for other states' waste. In particular, the issue has surfaced over a

Primary U.S./State Highway and Landfill Sites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Landfills
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SCALE
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FIGURE 1

Foth & Van Dyke

Engineers
Architects
Planners
Scientists

proposed municipal incinerator ash landfill which would accept wastes from out of state facilities.

RECENT LEGISLATIVE ACTION

The North Dakota legislative assembly enacted several new subsections to existing chapters of the North Dakota Century Code relating to solid waste management. The principle effort was to amend existing sections, enact new sections dealing with solid waste management, and provide for greater oversight of solid waste activities through the enactment of planning requirements and more stringent regulatory parameters for the management of solid waste. The result of the new law, which was signed on April 16, 1991 by Governor George Sinner, set in motion the development of proposed solid waste management and land protection rules. The rules were promulgated and released on October 1, 1991. The basic goal of the rules is to promote proper handling and disposal practices of waste generated within the state. The purpose is to protect the public health, safety and welfare, and to prevent land, water and air pollution. New draft rules provide for management of inert, municipal, and industrial wastes, as well as provide for infectious waste treatment, financial assurance, solid waste management fees, and solid waste management planning.

The state has set up eight solid waste management districts throughout the state following existing planning division lines. At this point, two districts have combined to start a preliminary solid waste study to ascertain the types of waste, volumes of waste, existing disposal sites, and collection and transportation in the district. The two districts, III and IV, comprise 12 counties in northeastern North Dakota. Included are two counties from a third district. The district configuration is illustrated in Figure 2.

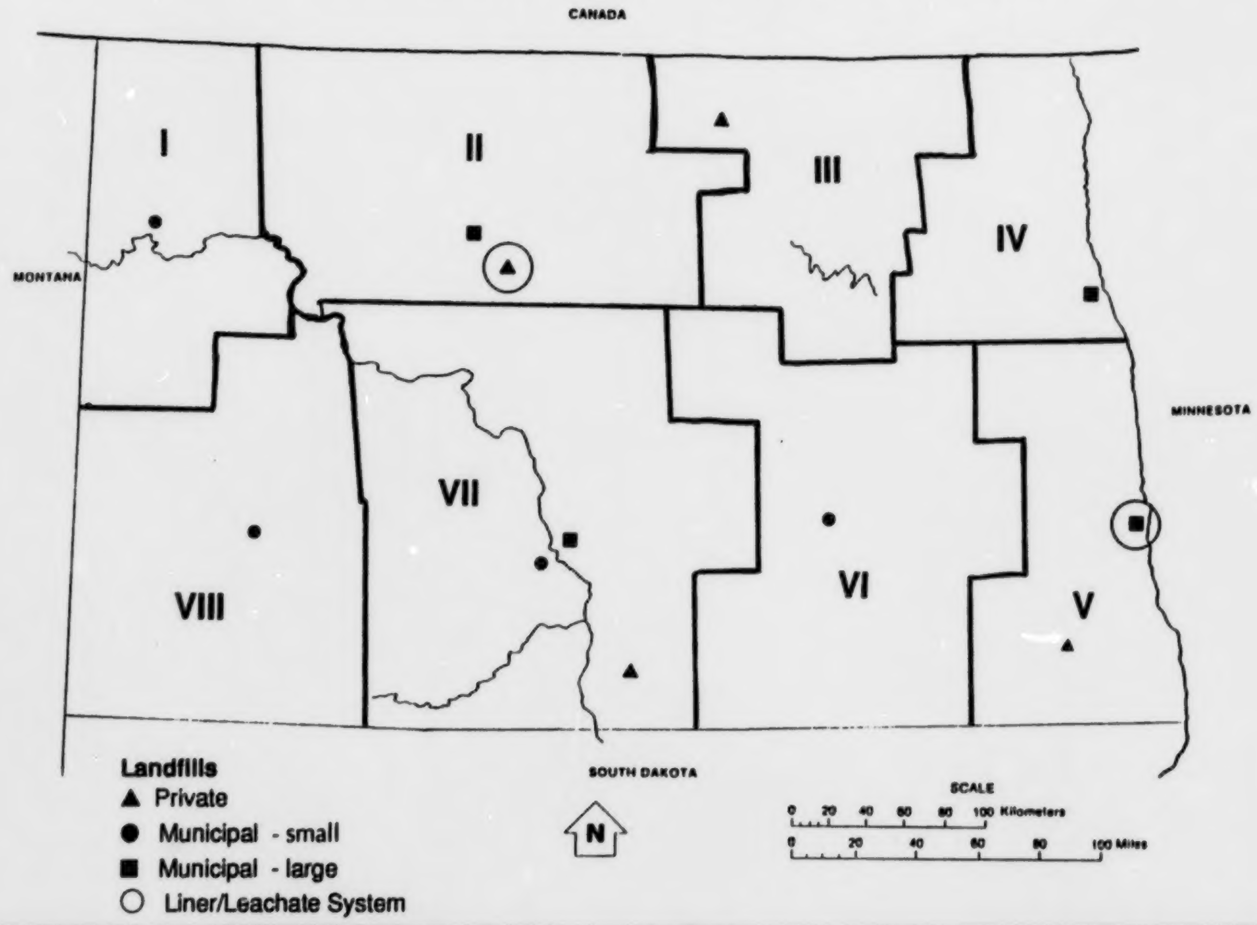
The recently enacted rules for the establishment of solid waste districts state: "By January 1, 1993, each waste management district shall submit a comprehensive solid waste management plan to the department for approval. The plan must include the districts' ability to properly manage and plan for adequate capacity, accessibility, and waste flow control. The plan must take into consideration existing waste transportation patterns and the ability of existing landfills to handle solid waste." Further, the rules require: "By July 1, 1993, the department shall incorporate all of the districts' solid waste management plans into a comprehensive state solid waste management plan." At point, private haulers and owners of waste disposal facilities are anxiously watching the development of the administrative structure of the districts. This is particularly critical since the issue of waste flow control is listed in the rules.

The governing board of each waste management district must include a representative of the waste haulers within the district, and a representative from a licensed disposal facility within the district. This allows for private sector involvement in the operation of the districts. Other members of the district include a representative from each county, and one representative from the cities within each county district. Since the laws and rules are relatively new, modification may take place. Likewise, the proposed solid waste management and land protection rules have not been finalized, and may be subject to legislative modification or modification through the hearing process in 1991 or 1992.

DISPOSAL CAPACITY

Within the State of North Dakota, according to NDSDH representatives, only two landfills have liners and leachate collection systems. The two are located in different parts of the state. The first is the City of Fargo Landfill, and the second one, privately owned, is the McDaniel Landfill located in Ward County near the City of Minot. Other landfills have

Waste Management Districts


CANADA
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SCALE
0 20 40 60 80 100 Kilometers
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Landfills
▲ Private
● Municipal - small
■ Municipal - large
○ Liner/Leachate System

FIGURE 2

Foth & Van Dyke

Engineers
Architects
Planners
Scientists

varying degrees of engineering including recompacted clay liners. However, no other facilities have a leachate collection system installed at this time. Most of the landfills are not engineered, having had limited design work completed for the facilities prior to construction. These facilities tend to be relatively small and serve relatively small populations with the exception of several of the large municipal facilities. Several landfills have had closure plans prepared in the past 2 to 3 years, which provide a greater level of design for the facilities.

The City of Fargo Landfill has a design volume of 3.8 million cubic yards and an expected life of 20 years at current loading rates. The McDaniel Landfill has a design of 2.5 million cubic yards and a life of 32 years. Change in loading rates would affect the life of either site.

POPULATION FACTORS

In order to better evaluate the disposal system in North Dakota, landfills have been ranked by population served. The 1990 Census was used with data from the NDSDH listing disposal facilities, population by minor civil division and hauler. These data were combined to provide an estimated population base per disposal facility, by geographic area. From this information and the 1990 Census for counties, major and minor waste areas were identified. Figure 3, Population by County, shows the wide variance in density in North Dakota. Only four counties have a population of over 50,000. The population of ten counties ranges between 10,000 and 25,000.

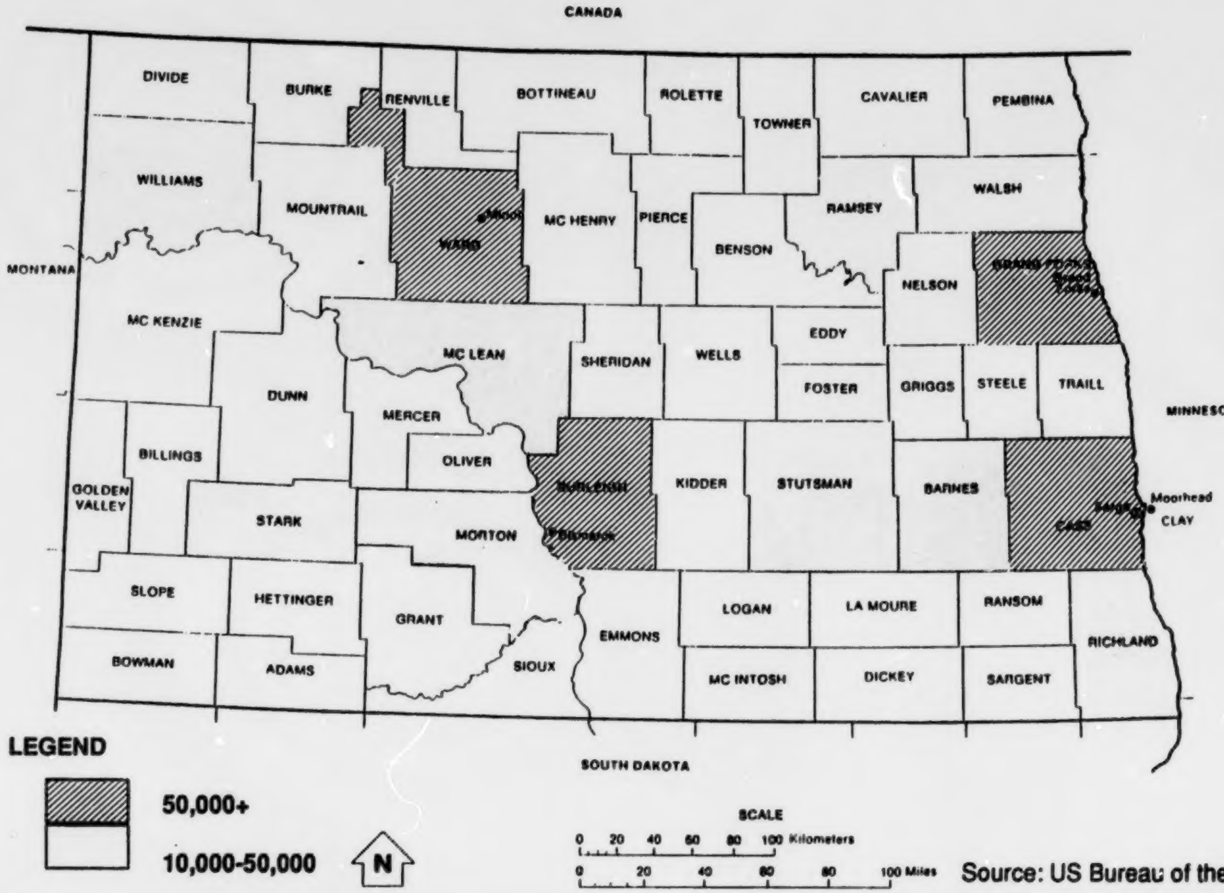
Using the criteria of population, and evaluating the facilities that are listed by the NDSDH, it becomes clear there are two primary levels of population base for landfills. The minor landfill service areas are based upon a population of 2,000 to 15,000 people. This is for both municipal and private landfills. Major landfill service areas are defined for the privately operated landfills as serving a population of 15,000 or more. Major municipal sites are divided into two levels. The first is 15,000 to 30,000, and the second is 30,000 or more.

Figure 4, Major Landfill Service Areas, illustrates the approximate area for the 11 private and municipal landfills catagorized as major. The population of these areas is approximately 390,000, or 61 percent of the state's total. Figure 5 shows the areas for landfills with a service area population between 2,000 and 15,000.

WASTE VOLUMES

The availability of disposal data is limited in North Dakota. Three facilities are known to have scales. These are the City of Fargo, the City of Grand Forks, and Big Dipper Enterprises, a private facility. Other facilities estimate gate volume by truck counts and daily records. Only two major private facilities are considered in comparing daily gate volumes in tons. These are the McDaniel Landfill in Ward County, which receives between 125 to 150 tons per day, and the Murphy Landfill located in Rollette County, receiving between 75 to 100 tons per day. The City of Fargo Landfill, with an average of 358 tons per day, is the largest site in the state in terms of volumes received. Table 1 lists tonnage figures for the largest sites in the state.

Population by County

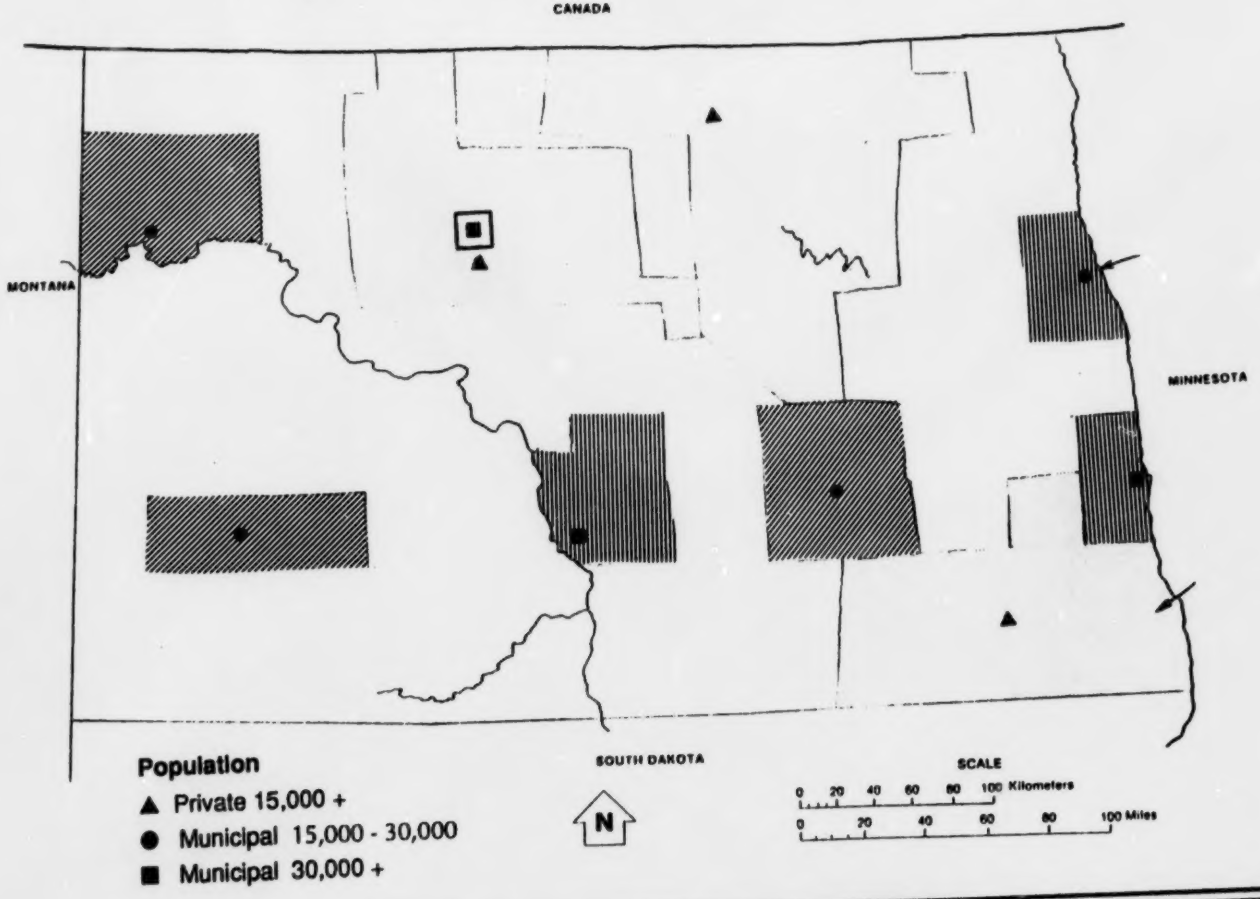

CANADA
DIVIDE
BURKE
RENVILLE
BOTTINEAU
ROLETTE
TOWNER
CAVALIER
PEMBINA
WILLIAMS
MOUNTRAIL
WARD
Minot
MC HENRY
PIERCE
BENSON
RAMSEY
WALSH
MONTANA
NELSON
GRAND FORKS
MC KENZIE
MC LEAN
SHERIDAN
WELLS
EDDY
FOSTER
GRIGGS
STEELE
TRAILL
MINNESOTA
DUNN
MERCER
OLIVER
BURLEIGH
Bismarck
KIDDER
STUTSMAN
BARNES
CASS
Fargo
Moorhead
CLAY
BILLINGS
GOLDEN VALLEY
STARK
MORTON
SLOPE
HETTINGER
GRANT
EMMONS
LOGAN
LA MOURE
RANSOM
RICHLAND
BOWMAN
ADAMS
SIOUX
MC INTOSH
DICKEY
SARGENT
SOUTH DAKOTA
LEGEND
50,000+
10,000-50,000
N
SCALE
0 20 40 60 80 100 Kilometers
0 20 40 60 80 100 Miles

Source: US Bureau of the Census

FIGURE 3

Foth & Van Dyke
Engineers
Architects
Planners
Scientists

Major Landfill Service Areas


CANADA
MONTANA
MINNESOTA
SOUTH DAKOTA
Population
▲ Private 15,000 +
● Municipal 15,000 - 30,000
■ Municipal 30,000 +
N
SCALE
0 20 40 60 80 100 Kilometers
0 20 40 60 80 100 Miles

Foth & Van Dyke Engineers Architects Planners Scientists

FIGURE 4

Minor Landfill Service Areas

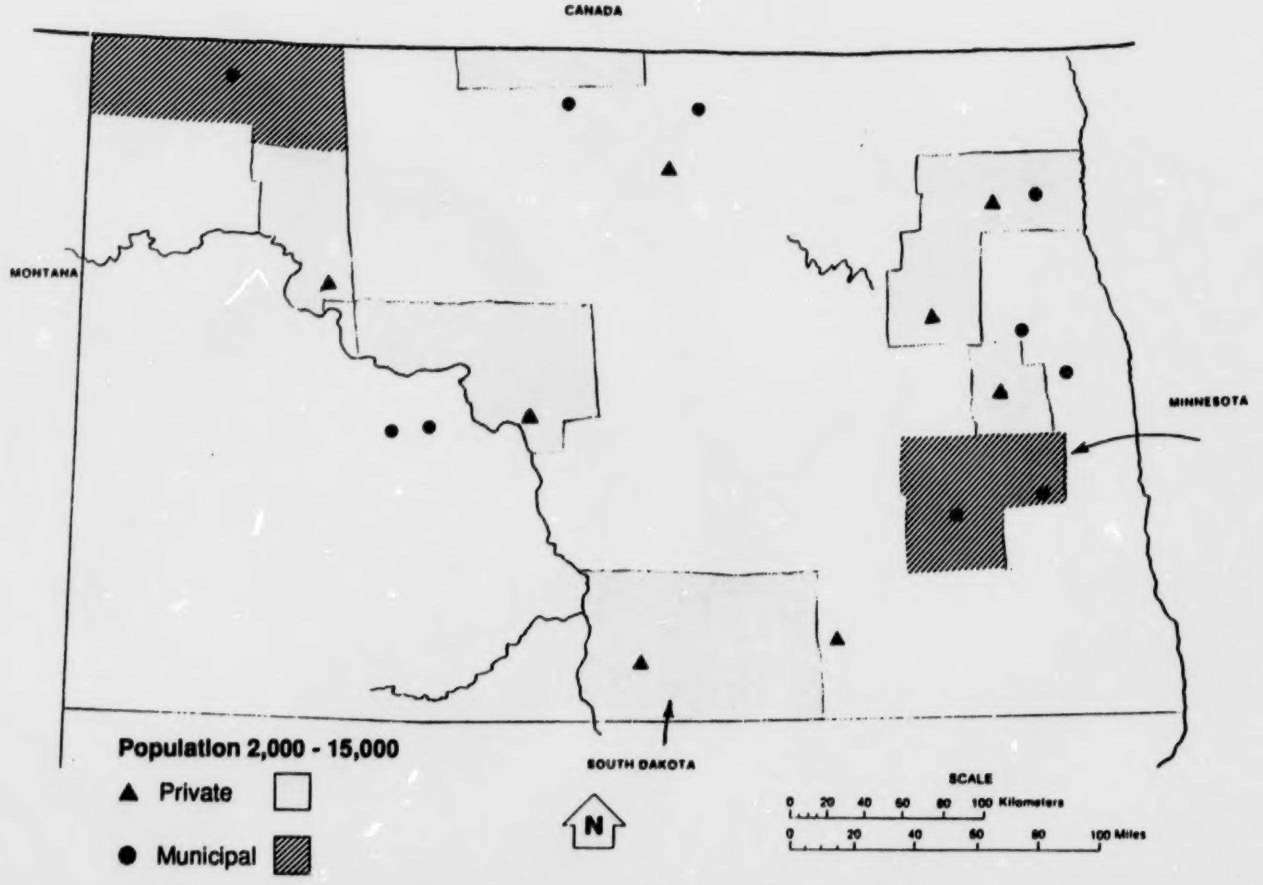

CANADA
MONTANA
MINNESOTA
SOUTH DAKOTA
Population 2,000 - 15,000
▲ Private
● Municipal
N
SCALE
0 20 40 60 80 100 Kilometers
0 20 40 60 80 100 Miles

FIGURE 5

Foth & Van Dyke
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Architects
Planners
Scientists

TABLE 1

SITE	DAILY/ANNUAL (TONS)
City of Fargo	358/93,190
City of Grand Forks	275/71,500
City of Minot	131/34,000
City of Bismarck	154/40,000
Big Dipper Enterprises	170/44,200
McDaniel	150/39,000
Murphy	100/26,000

Note: Fargo, Grand Forks, and Big Dipper Enterprises have scales at the landfills. Others based on daily truck loads. Data includes out of state MSW

Source: Data obtained from personal communication with landfill operators in 1991.

COLLECTION AND TRANSPORTATION

According to the NDSDH, collection patterns within the state show that several of the landfills serve a geographic area that is quite large. There is within the state one landfill which is receiving wastes from approximately a 100 mile radius. Two other private landfills are receiving wastes close to the 100 mile radius limit. Other private landfills are shown to receive wastes from throughout one or more counties, often by several haulers.

The municipal sites tend, for the most part, to receive wastes from a more limited area than private sites. Several exceptions occur, however. Jamestown receives virtually all of the waste within Stutsman County. Valley City in Barnes County also receives nearly all of the waste from that county including, according to records, some waste from two adjacent counties, although the volume is very limited. Dickinson, located in Stark County in western North Dakota, receives waste from three counties according to NDSDH records. The four largest municipal sites all receive wates from generators outside of the municipality. Estimates by Grand Forks are that 40 percent of the total volume is from outside of the city.

The City of Castleton, in Cas County, Grand Forks, and the Big Dipper landfill in southeastern North Dakota receive wastes from several Minnesota counties. Big Dipper also operates a transfer facility in Wahpeton, North Dakota, 50 miles from their landfill. Although records are not available, one hauler said he collects some waste from South Dakota. The importation of wastes from other states is economically driven. Disposal capacity is available and the availability of transportation routes provides economical export of wastes.

According to the State of North Dakota, effective September, 1991 there were 120 licensed waste haulers operating in North Dakota. This includes 113 from North Dakota, one from Montana, five from Minnesota, and one from Saskatchewan, Canada. Most of the hauling companies are small operations with relatively few vehicles. Some operate larger fleets and cover either larger population areas, such as the City of Fargo, the City of Bismarck, and the City of Minot, or are private haulers in larger geographic areas who haul to landfills which they own, or to landfills close to where the waste is generated.

Figures No. 4 and 5, again, show relative collection areas by landfill. These figures do not accurately represent the total collection picture but rather an overview of what appears to be transpiring within the counties. These figures are based upon number of haulers hauling to these particular landfills from throughout, what becomes, the service area of the landfill. Several haulers may be utilizing a particular landfill to create the service area.

SERVICE AREAS BY MAJOR LANDFILLS

Figure No. 6 illustrates the service radii of private and municipal landfills designated as major landfills. The radius for each of the three private landfills shown is between 80 and 100 miles. This is based upon the current extent of collection for the facilities. The actual range of one of the facilities extends beyond 100 miles and into Minnesota.

Figure 4 shows the municipal landfill service areas of facilities which take waste from outside their municipal city limits. The largest such facilities are the Fargo and Grands Forks Landfills. The City of Bismarck takes most of the waste from Burleigh County. Some waste from Burleigh County goes to a private site, but the exact amount is not known. The other facilities shown on Figure 4 are Williston in far northwestern North Dakota, which takes waste from within most of Williams County; Dickinson, which takes waste from most of Stark County and two adjacent counties; and Jamestown, which takes most of the residential and commercial waste from Stutsman County. These facilities constitute the largest municipal landfills in terms of area served. Two other facilities, Minot City and the Mandan City Landfills, receive wastes from several small communities. Both facilities serve a large population.

PLANNING DISTRICTS

As previously mentioned under the legislative section of this paper, North Dakota has set out planning districts for solid waste management functions. Figure 2 shows the planning districts that exist at this time. The districts are set up to match existing planning areas and not necessarily areas which will facilitate prudent solid waste management planning. The districts can join together with other districts or parts of other districts to expedite the solid waste management planning process and ultimately the development of a system.

Given the geographic coverage under districts shown in Figure 2, and the distribution of existing large waste facilities, the current districts could be realigned as shown in Figure 7, to more accurately reflect several factors. The first factor would be the realigned districts represent areas currently served by public and private landfills more closely than under the existing district system. Districts III and IV, as shown on Figure 2, have already combined for planning purposes shown as District III, as shown on Figure 7. The transportation system currently utilized by private haulers within the State of North Dakota appears to follow the suggested realignment pattern. This is reflective of the current distribution of population, disposal facility location, and physical boundaries. The physical boundary issue is most prevalent in the western part of the state along the Missouri River due to the limited number of bridges in the area. Realigned Districts II and III coincide with the service areas of two of the large private landfills. Within those two districts there is some overlap, although not a great deal.

The major problem with setting up any district based upon existing facilities is that the life expectancy of an existing disposal facility can not be foresen. As previously mentioned, only two facilities in North Dakota have liners and leachate collection systems.

Major Landfill Service Radii

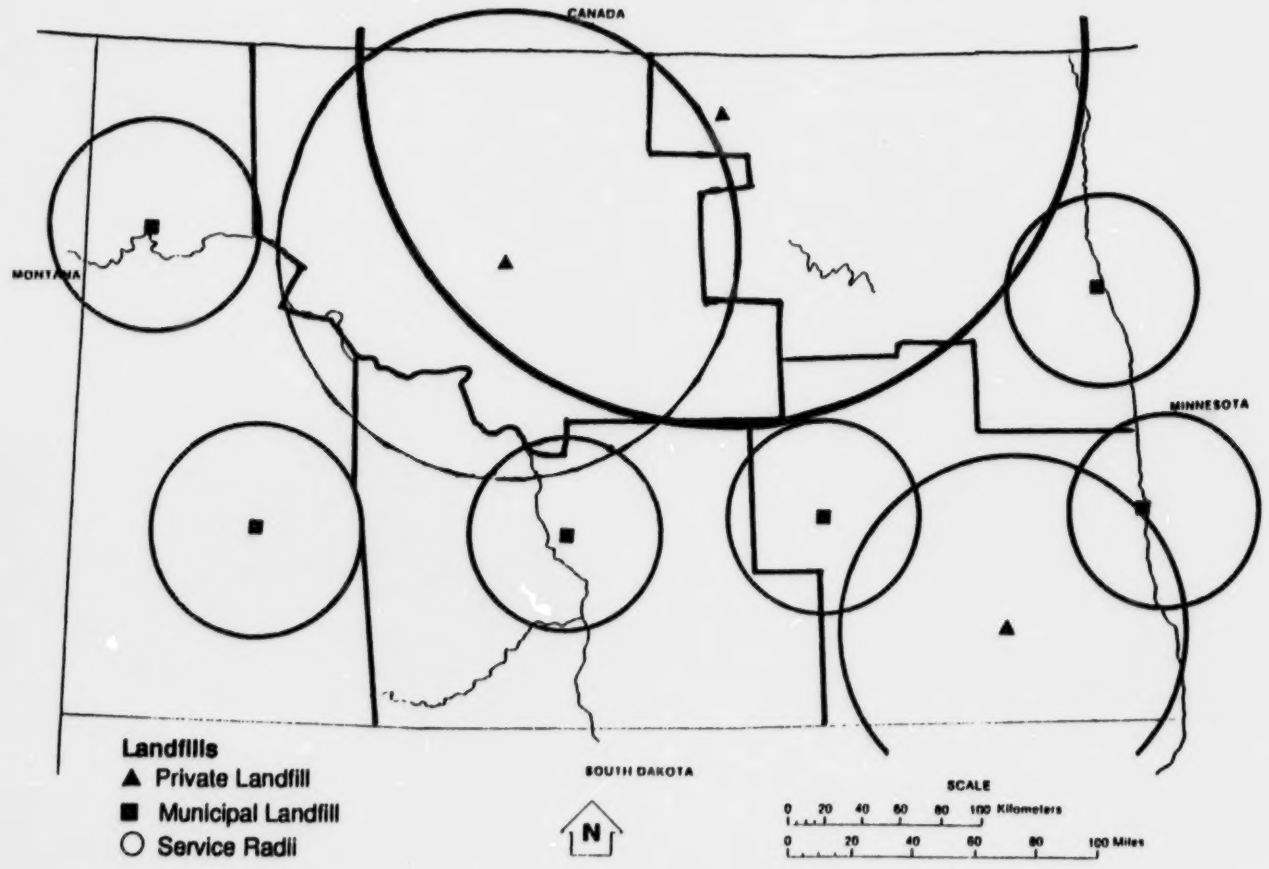
CANADA
MONTANA
MINNESOTA
SOUTH DAKOTA
Landfills
▲ Private Landfill
■ Municipal Landfill
○ Service Radii
N
SCALE
0 20 40 60 80 100 Kilometers
0 20 40 60 80 100 Miles

FIGURE 6

Foth & Van Dyke Engineers Architects Planners Scientists

Potential District Realignment/Landfill Radii

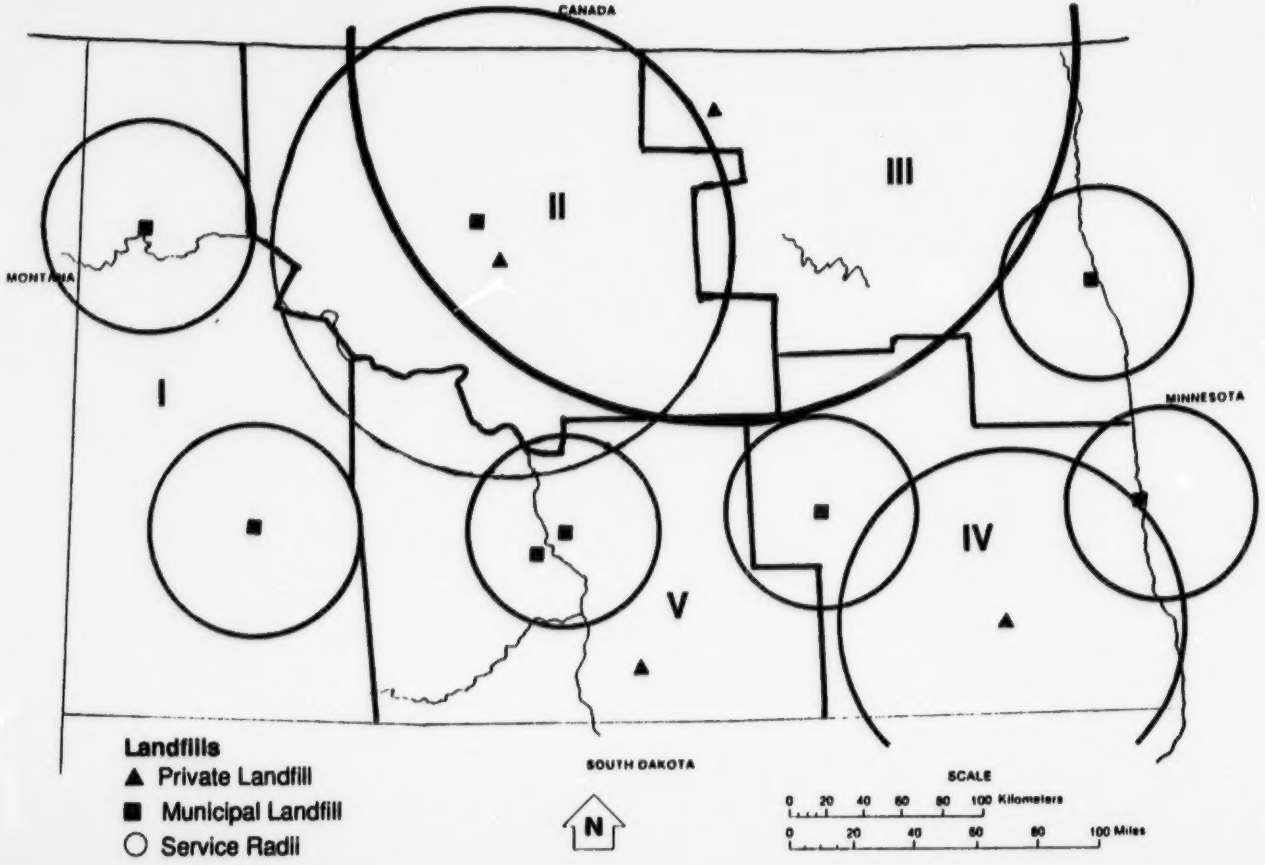
CANADA
MONTANA
MINNESOTA
SOUTH DAKOTA
I
II
III
IV
V
Landfills
▲ Private Landfill
■ Municipal Landfill
○ Service Radii
N
SCALE
0 20 40 60 80 100 Kilometers
0 20 40 60 80 100 Miles

FIGURE 7

Foth & Van Dyke
Engineers
Architects
Planners
Scientists

It is assumed that both the facilities will remain in operation for the length of their permit and design capacity. The other facilities illustrated on the various figures offer potential sites for expansion of most of them. Should, for whatever reason, private or public facilities be closed, the planning issue and the district boundaries become somewhat blurred. The development of a multi-county, or regional plan, identifying potential areas where a disposal facility may be needed does not guarantee that such will ever be constructed.

The population distribution by districts, whether the existing or any realignment of districts, is perhaps not the critical issue facing North Dakota. Disposal facilities can be designed where physical space is adequate to accommodate virtually any size population. In essence, one landfill could easily be developed to serve the entire State of North Dakota for a 10 to 15 year period without utilizing more than 640 acres of land. The issue becomes one of allowing for the efficient collection and transporting of waste to facilities which meet state and federal regulations and are located in reasonable proximity to where the waste was generated. Since population density per square mile in much of North Dakota is extremely low, transportation becomes a bigger issue. Transportion of waste for distances of 75 to 100 miles is not, according to private haulers, an economic burden on generators of waste. Rates are relatively low in comparison to other states and the collection system functions today quite well.

Table 2 shows the population of the existing districts and the potential realignment.

TABLE 2

Waste Management District Population

District	Existing	Realignment
I	30,400	71,500
II	90,400	109,300
III	45,900	155,200
IV	98,100	184,900
V	142,700	118,100
VI	66,200	-
VII	123,900	-
VIII	41,100	-

SYSTEM DESIGN

Based upon available information and the intent of North Dakota to proceed into solid waste management planning, waste reduction, recycling, and district management or oversight of solid waste management, it appears that a new system of disposal and transportation will be developed. On the disposal end of the equation, the number of landfills can affectively be reduced to several medium to large sized facilities, having disposal design capacities of between 1,000,000 and 5,000,000 cubic yards of air space. The location of the facilities can be based upon new sites, or upon existing sites where space is available to expand following new design regulations. Combination of municipal and private landfill opportunities, as exist today, is a good system. The system, however, should recognize that private facilities find it difficult to justify spending financial resources to design a new landfill without the assurance that the wastes are available for disposal. In order to allow for that, smaller facilities that have the potential to, or have caused environmental impacts need to be closed within the rules of the NDSDH and U.S. EPA regulations. Promulgation of numerous small facilities, even those exempted under EPA's rules, would only encourage the continued disbursement of waste into unlined and potentially environmentally sound facilities.

More than likely, the system would function efficiently if communities that have their disposal facility closed, have a transfer station, or facility such as a stationary compactor system, installed in place of the landfill. Hauling to a regional transfer facility may prove to be an effective way of handling the sparsely populated parts of the western area of North Dakota. Weekly collection is required by the state rules.

Hauling from the widely dispersed population in the state will probably require an evolution in equipment for some of the haulers, as well as a change in the pattern of collection and disposal of the MSW. Places where the local landfill is closed, and where people have provided their own hauling of wastes, large containers or a stationery compactor may prove to be an effective replacement for the local landfill. The collection then is provided on a regional basis as a hauler picks up, depending on the volume generated, one or more times per week. The development of small transfer facilities where waste can be placed in transport trailers may prove practical. Landfill location will also impact on the collection and transport of MSW. Many haulers will haul directly to the landfill as the utilization of larger trucks proves more economical than utilizing two or more types of trucks to haul waste over the same distance via a transfer station.

An unknown part of any system will be the willingness of municipally owned landfills to accept waste from beyond the limits of that municipality. If a facility is designed to serve only the municipality, development of additional disposal capacity would be required for the remaining area of any planning district. The refinement of the system in terms of landfill design capacity and communities participating with the municipality will be ironed out over time as the districts become more active in the roll of developing solid waste management systems.

SOCIAL ASPECTS

Overriding much of the views of waste haulers, both municipal and private landfill owners, and state regulators will be the acceptance or rejection of any system by the people of North Dakota. Old patterns of handling MSW are hard to change. The removal of local disposal options by the closing of small, inefficient, or environmentally unsound landfills will cause, in many cases, a backlash from the local populace. The tendency is to not want to see the local landfill closed, yet not support the development of the new facility if it is nearby. In order to mitigate the influence of this, the collection systems that are most reliable will be those that will maintain the frequency of past collection, as well as possibly utilizing the old facility or a facility nearby for placement of stationary compactors or containers. The familiarity with using a waste disposal area in rural areas tends to become ingrained upon the citizenry. This is less of an issue in larger cities, but in the more rural areas it may be an issue.

The development or the expansion of disposal facilities will undoubtedly cause concern and possibly opposition. A site in North Dakota has recently been developed for municipal incinerator ash. The opposition included residents and nonresidents of North Dakota. The resulting awareness by people of that facility may impact on the siting of new or expansion of existing facilities. Unfortunately, it is not possible to predict the reaction of people within an area to having small landfills closed and the development of a new, much larger facility proposed within their area. The actual impact would be negligible or nonexistent to the people. However, the opposition may still stridently reject a new site.

The key to minimizing social impacts of the changing system which North Dakota is facing is to see that the planning districts actively work to dissimilate information and to represent as broad a spectrum of people as possible within the area. It is critical that residents of the districts understand the cost of solid waste management, and the cost of not correcting a disposal situation that is environmentally threatening or otherwise causing problems. The positive benefits, economically and environmentally, of solid waste management needs to be stressed by the districts.

ECONOMIC ISSUES

At the top of the economic issue list facing North Dakota is the promulgation of new state and federal rules which, if carried out to the maximum extent allowable, will require the closure of the vast majority of the disposal sites in North Dakota. Of the nearly 50 landfills which are operating in the State of North Dakota, it is estimated that only a very few will continue to operate under the new rules. The cost associated with closing the sites will be born by the users of the sites. Final closure, under North Dakota rules, will mean that site owners will have to expend funds to properly cap their landfills. The North Dakota rules do not require groundwater monitoring as part of closure activity. However, should the department determine that groundwater may be adversely impacted, monitoring wells may also be required.

The cost of this is unknown, obviously. Likewise, the cost of developing new facilities or expanding existing ones are difficult to ascertain given the uncertainty of waste flow control under the new North Dakota rules. Conversations with several operators of landfills are indicating a "wait and see" attitude as to whether or not to expand, or to develop a new facility, or to simply close the existing facility.

The cost associated with the development of a new facility in North Dakota can be expected to range between $500,000 and $1,500,000 through construction of the first phase of a 20 acre landfill. Costs would include land, construction, engineering, monitoring, testing, etc. These costs can easily be pushed beyond $1,500,000 for a larger facility requiring more extensive work.

The issue of transportation of solid wastes will become more important as existing landfills are closed. As previously discussed in this paper, private operators are hauling waste from approximately 100 mile radii into private and public landfills. With over 100 licensed waste haulers in the state, the competitive marketplace will set hauling prices for many of the businesses. Some data have shown projected hauling costs of $1.05 to $1.50 per mile for residential wastes. Ranges can be expected to vary given the equipment utilized by any particular hauler, the length of the haul, and the competition for business. Given the lack of data available, it would be very difficult to estimate total transportation costs for the state.

Some haulers have indicated a preference for using packer or roll-off trucks for haul distances approaching 100 miles. The major setback to utilizing transfer trailers is the low population density found throughout most of state. It is more economical to run one truck the entire length of the route, if properly set up to allow for efficient use on highways, rather than investing in additional equipment and using a transfer trailer system. Whether this type of arrangement remains cost effective will depend upon the number of haulers that remain in the business and whether or not the landfill closure issue proceeds to the point where there are only a very few number of sites remaining open.

In the course of determining the economic impacts, the issue of landfill ownership and operation, surfaces. The municipalities of the larger facilities may restrict use to residents within a narrow geographic area versus becoming a regional facility. Conversely, some of the large municipal operations may wish to become the regional facility and develop much larger landfills, thereby encouraging the importation of wastes into their facility, which may lead to municipalities competing with existing private landfills. Since the waste centroides are concentrated in several cities in the state, this may prove to be an issue as the districts develop their regional plans.

As illustrated in Figure 6, service radius for the major landfills in the state indicates the municipal sites are limited in service area, while the three major private landfills have much larger service areas. Assuming that this pattern remains in the near future, landfill expansion projects can be limited to a few sites throughout the state. However, should any of the facilities choose not to maintain the operating status as a landfill, the displacement may cause a shift in both transportation, and the location and development of future disposal sites.

The issue of collecting waste from other states is relatively unnoticed by most of the residents of North Dakota. The economic impact of the transport and disposal of out of state wastes into the state is that it provides revenue for the landfill owner and for the hauling companies that are involved in the transport of the wastes. It does not appear to negatively impact the volume of landfill space currently available throughout the State of North Dakota. It does, however, positively improve the financial performance of each site.

Placing specific costs or cost estimates to collection and disposal in North Dakota would be difficult to do, given the current landfill distribution and size pattern, as well as the multitude of haulers in the state. Tipping fees at landfills range from below $10 to near $20 per ton. Apparently some very small sites do not charge haulers to dump. This complicates any attempt to analyze the real costs for the system. Urbanized collection is not expected to change significantly in the large cities over the course of time since it is structured in its operation.

Coupled with the waste reduction and recycling goals that the State of North Dakota has adopted, one can expect to see shifts in the costs of solid waste management for many of the communities. Disposal costs will become part of transportation costs for many of the communities. Residual costs will be incurred for the closure of small landfills. Costs will more than likely be broken out in certain areas by collection, transfer station, and then transportation costs and disposal in another site, in another part of the state. This will primarily affect the rural areas that are relying at this point on the small municipal landfills. Tipping fees at landfills will increase as the new generation landfills are constructed. In the case of public facilities, the actual method of covering those costs may vary. Costs associated with the new design requirements for expansion or development of new private facilities will be factored into the tipping fees. The end result will be an increase over time in disposal costs associated with waste management in North Dakota.

SUMMARY

Residents of North Dakota, over the course of the next several years, will see a change in the way solid waste is managed through its collection and disposal. If the regional concept as proposed by the state follows through, residents can expect to have a significantly reduced number of landfills remaining in the state, transfer stations may become more common, and generally, higher costs for disposal.

The flexibility allowed by the legislation to enable solid waste management districts to control waste flow will probably be tested. Until detailed regional studies are completed, actual disposal costs, and collection, transportation, and disposal routes will be unknown. The lack of data on solid waste management at the state level will become less of a problem as the regional plans are completed. Data developed in the planning process will enable decision makers and those involved in the solid waste management industry to better ascertain the actual system in North Dakota. At this particular time it is difficult to pin point the system in great detail due to its fluid nature of haulers and the number of small landfills which are utilized throughout the state. Records on volume disposed of are very few. The end result of this can be the development of a system which is based upon a better understanding of the volumes of waste and transportation and disposal patterns, as well as the economic impacts of that system. The continued existance of numerous small dumps will negatively affect the economic resources of those landfill owners who have, or who plan to, invest in new generation facilities meeting state and federal regulations.

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OUT OF SITE, OUT OF MIND? THE COMPATIBILITY OF REGIONAL DISPOSAL AND WASTE MINIMIZATION IN THE PACIFIC NORTHWEST

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Long-distance transportation of solid waste from its source to disposal in another jurisdiction has been the subject of much concern and debate in recent years, especially in the in the eastern United States where shipments of waste from New York and New Jersey to disposal sites in Pennsylvania, Ohio, Indiana and Kentucky have aroused heated controversy and calls for congressional action.[1] The National Solid Waste Management Association has estimated that in 1989 about 15 million tons, or about 8 percent of all municipal solid waste generated in the United States, was involved in interstate transport.[2] Since 1989, interstate shipments of solid waste have probably increased, and congressional action to limit or regulate interstate disposal may be imminent[3].

The reasons for concern on the part of host jurisdictions are often well founded: scarce landfill resources that were originally developed for the welfare of the local population are suddenly being consumed by the cities of another region. There may be no compensation of the local population for the cost and inconvenience of siting replacement disposal capacity, or for other public costs not reflected in the landfill tipping fee. Worse, at a time when many communities are attempting to preserve local landfill capacity through costly waste reduction and recycling programs, a host jurisdiction typically has no means of assuring that the exporting jurisdiction is making similar efforts.

Though the national debate focuses on interstate garbage transfers, similar issues can arise for intrastate shipments between counties or other units of government with responsibility for solid waste management and planning. The exporting communities are often accused of adopting an "out-of-site, out-of-mind" solid waste management policy, shifting the burden of disposal to another county in lieu of developing their own disposal resources and aggressively reducing the amount of waste needing disposal.

However, recent developments in the Pacific Northwest demonstrate that long-distance transport and disposal of solid waste (often referred to in the region as "waste export" programs) can be combined with aggressive waste minimization programs. The City of Seattle and other cities and counties in the Pacific Northwest have been recognized as leaders in the development of innovative waste reduction and recycling programs. These efforts have often been combined with the development of a large-scale regional disposal system in which waste from the most populous regions of Washington and Oregon is transported distances of 150 to 350 miles to regional landfills in the arid eastern regions of these states. The system involves both interstate and intrastate shipments. Implementation of the system has not been without its challenges, but the region's success is tangible and rests on a few significant institutional and economic arrangements that may be applicable in other regions, as well.

This paper describes the developing regional waste management system in Washington and Oregon and describes the economic and institutional conditions that have supported both local waste minimization and efficient trans-jurisdictional disposal.

THE WASTE EXPORT INDUSTRY OF WASHINGTON AND OREGON

Solid waste disposal practices have changed dramatically in the Pacific Northwest since the mid-1980's. The trend has been away from local publicly owned and operated dumps and landfills, toward large regional disposal facilities located in rural areas, owned and operated by the private sector. In Washington the number of operating municipal landfills has declined from more than 200 in 1984 to about 50 today, and has declined in Oregon from more than 200 in the late 1970's to about 100 today.[4] Several local governments have begun to export their wastes to regional facilities because of the risk, expense and local opposition associated with developing new landfills in the more populous areas of the region, and because of economic and environmental advantages provided by sites located in arid regions east of the Cascade Mountains. The major waste export projects in the Pacific Northwest are described in Table 1, and the geographic location of the exporting jurisdictions and the regional landfills is shown in Figure 1.

Recent state regulations governing landfill design and operation have led to increases in both the total cost and economies of scale of landfill development. The result has been a decline in the cost of transporting waste relative to the cost of disposal, thereby increasing the feasibility of large regional landfills. Currently the total cost of waste export, including transportation from coastal population centers in the Pacific Northwest and disposal at regional landfills in eastern Washington and Oregon ranges between about $38 and $45 per ton. These costs are often competitive with the cost of developing local landfills in the west, especially given the uncertainty associated with the siting and regulatory process.

These economic conditions have arisen in conjunction with both a decline in the availability of land suitable for large disposal facilities, and in public opposition to the siting of such facilities in the urban areas of the Pacific Northwest. In contrast, the rural areas of the Pacific Northwest are endowed with many suitable sites for large landfilling operations. The dry climate east of the Cascade Mountains provides both cost and environmental advantages over areas west of the Cascades, and the benefits of increased economic activity in the relatively small economies of eastern counties often outweigh public opposition.

In the eastern United States many out-of-region waste shipments are conducted relatively informally by private waste management firms. In contrast, in the Pacific Northwest most waste is exported under the terms of a contract between a city or county and the owner of a regional landfill, selected by the exporting jurisdiction through a competitive procurement process. These contracts usually give the exporting jurisdiction a high degree of control over technical and administrative aspects of the disposal program, and effectively extend state and local regulatory control of waste handling operations beyond state and local boundaries. As examples, the waste export programs of the Metropolitan Service District of Portland, Oregon, the City of Seattle, Washington, and Snohomish County, Washington are described below.[5]

Table 1
REGIONAL LANDFILLS IN THE PACIFIC NORTHWEST

FACILITY NAME (Developer)	CURRENT STATUS	CONTRACTS	METHOD OF PROCUREMENT	TOTAL CONTRACTED[a] (Thousands of Tons/Year)	APPROXIMATE CAPACITY (Thousands of Tons)
Columbia Ridge (OR) Waste Management of Oregon	Open as of January 1990	Portland Metro, OR Seattle, WA Kennewick, WA	BID RFQ/P N/A[b]	1,100	60,000
Roosevelt (WA) Rabanco	Open as of fall 1990	Snohomish County, WA Spokane County, WA	BID RFQ/P	500	40,000
Finley Buttes (OR) Tidewater Barge Lines	Open as of November 1990	Clark County, WA Pacific County, WA	RFQ/P RFQ/P	200	30,000
					130,000[c]

[a] Totals exclude waste received from private-sector customers.

[b] No procurement. A Waste Management subsidiary provides hauling services to the city.

[c] Equal to rougly 20 years of Washington and Oregon's MMSW disposal needs at 1990 levels. Does not include additional capacity that may be available through expansion.

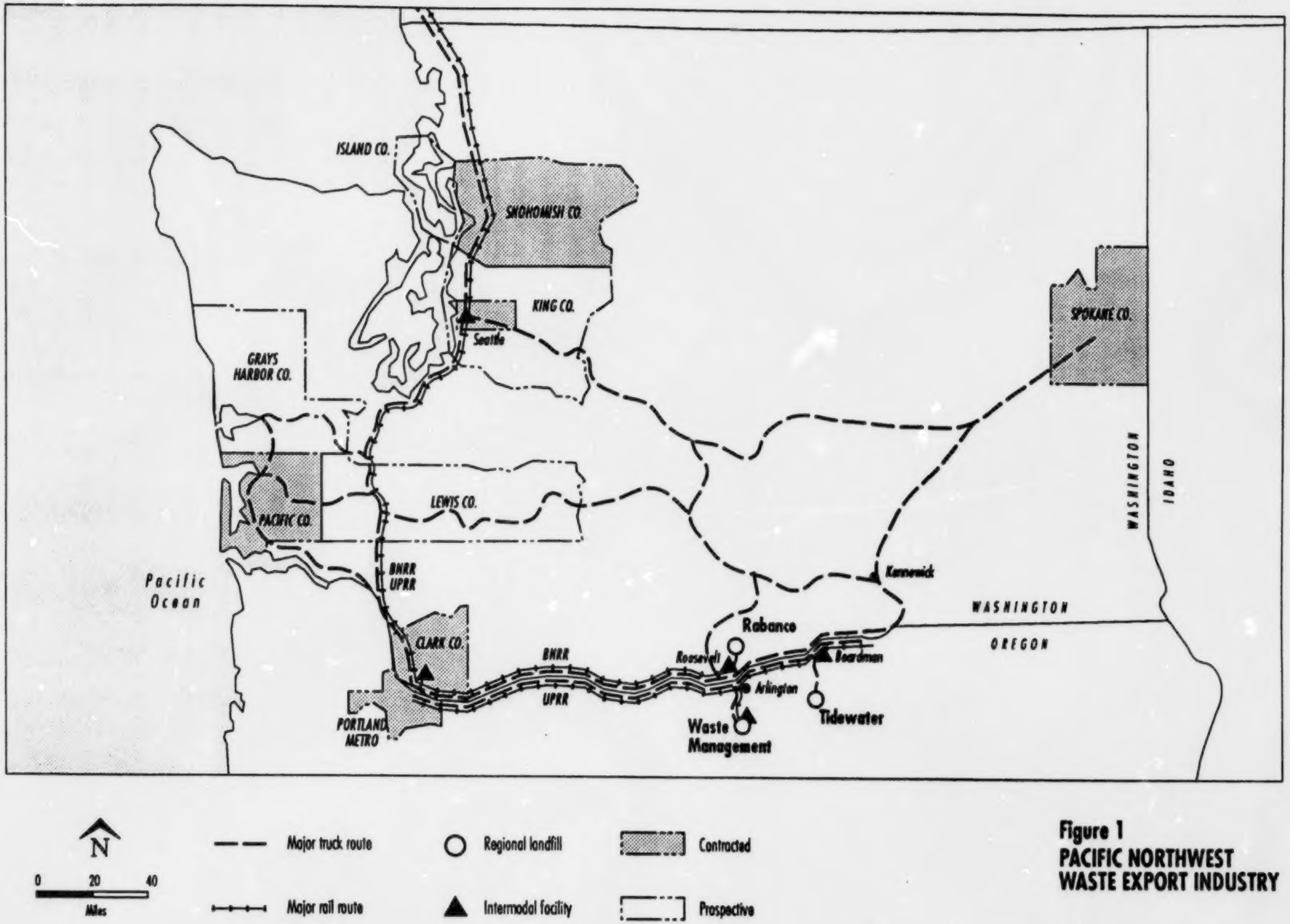
ISLAND CO.
SNOHOMISH CO.
KING CO.
Seattle
GRAYS HARBOR CO.
SPOKANE CO.
LEWIS CO.
PACIFIC CO.
Pacific Ocean
BNRR
UPRR
CLARK CO.
PORTLAND METRO
Kennewick
WASHINGTON
IDAHO
OREGON
Rabanco
Roosevelt
Arlington
Boardman
Tidewater
Waste Management
N
0
20
40
Miles
Major truck route
Major rail route
Regional landfill
Intermodal facility
Contracted
Prospective

Figure 1
PACIFIC NORTHWEST
WASTE EXPORT INDUSTRY

Metropolitan Service District of Portland, Oregon

The Metropolitan Service District of Portland, Oregon (Portland Metro), a government services agency representing metropolitan Portland, Oregon began operating a waste export program in January 1990. Services were procured using three sequential requests for disposal, transportation, and transfer/materials recovery services.

In April 1988, through a bid process, Portland Metro awarded a 20-year contract for disposal to Oregon Waste Systems (OWS), a division of Waste Management Inc. (WMI). OWS began operation of the Columbia Ridge Landfill in Gilliam County, Oregon in January 1990. Initially, about half of Metro's waste stream was transported to the OWS landfill, with the rest going to the St. John's Landfill near Portland. Once the St. John's Landfill was closed in early 1991, Portland Metro's remaining non-recycled wastes were transported to Columbia Ridge for disposal.

The transportation portion of Metro's waste disposal system was also awarded by a bid process to a trucking firm, Jack Gray Transportation, in March 1989. Jack Gray transports compacted wastes in specially designed transfer trailers 160 miles east to Columbia Ridge Landfill. Through a combination of pre-loading compaction and light-weight trailer design, the trailers are carrying an average payload of nearly 30 tons.

In addition to an existing recycling and transfer station that is owned by Portland Metro and operated by OWS, Metro awarded a contract for the construction and operation of a second transfer station near the St. John's Landfill to Trans Industries, Inc., a joint venture between Rabanco and Browning Ferris Industries (BFI). Trans Industries is required to recycle a minimum of 28 percent of the waste stream entering the transfer station. Metro further encourages recycling by paying Trans Industries the avoided cost of transportation and disposal saved by recycling. Source separated materials are not included in meeting the recycling requirement.

City of Seattle, Washington

The City of Seattle recently contracted with Washington Waste Systems (WWS), a subsidiary of Waste Management of North America, for waste export services. The contract is for 38 years, with the City retaining an option to terminate the contract after either 10 or 25 years. OWS was selected through a request for qualifications/ proposals (RFQ/P) procurement which began in March 1989. Seattle has established curbside collection for recyclable materials and many other aggressive recycling programs, and began exporting its solid waste in April 1991.

At transfer stations located in the city, non-recycled solid waste is compacted and loaded into sealed shipping containers mounted on trailer chassis. The containers are transported by truck to an intermodal rail loading facility operated by the Union Pacific Railroad (UPRR) in Seattle. At this facility, containers of compacted waste are temporarily stored or loaded directly onto trains for transport to the Columbia Ridge Landfill. The waste is transported by double-stack unit train to the landfill 3 times per week. At the landfill, the shipping containers are taken off the rail car, unloaded with a tipper, and placed back on the rail car for the return trip to Seattle for reloading.

Seattle currently disposes of approximately 1,100 tons of solid waste per day. The City's contract with WWS includes no guarantee of solid waste quantities in order not to allow restrict future waste reduction and recycling initiatives.

Snohomish County, Washington

In May 1990, Snohomish County entered into a seven-year contract with Rabanco Regional Landfill Company for solid waste transport and disposal services, with two seven-year renewal options. Rabanco was the low bidder in response to a request for bids issued by the County in September 1989. Rabanco is scheduled to begin acceptance of the approximately 1,100 tons per day of non-recycled waste generated within the County in November, 1991.

Snohomish County will operate its existing and planned recycling and transfer stations. At these stations, non-recycled solid waste will be compacted into sealed shipping containers for delivery by truck to an in-county intermodal receiving facility operated by Rabanco. At the intermodal facility, containers will be transferred from trucks to rail cars. The Burlington Northern Railroad will transport containers by rail to an intermodal facility in Roosevelt, Washington where the containers will be loaded onto trucks for the final five miles of transport to the landfill.

SOLID WASTE MANAGEMENT PLANNING AND WASTE MINIMIZATION IN THE STATES OF WASHINGTON AND OREGON

In recent years, the states of Oregon and Washington have established solid waste reduction and recycling policies that extend aggressive waste minimization programs to nearly all communities within the states. Within the urbanized areas around Portland and Puget Sound, cities and counties have undertaken even more aggressive recycling programs, and several are nationally recognized for their innovations and achievements in the areas of waste reduction and recycling. By establishing waste minimization as the first in a hierarchy of solid waste management measures, both the specific recycling programs of the cities and counties exporting waste, and the statewide systems of solid waste management planning and regulation have helped to ensure that the regional waste export industry operates in conjunction with aggressive waste reduction and recycling initiatives.

State Solid Waste Management Requirements

Washington. In the State of Washington, duly adopted and approved Comprehensive Solid Waste Management Plans (CSWMPs) are the principal instrument used by the Washington Department of Ecology ("Ecology"), local Health Districts, and municipalities to oversee and regulate solid waste management activities in their jurisdictions. In general, any solid waste handling facility must have an operating permit issued by the local Health District confirming that the siting, design and operation of the facility is consistent with the current local CSWMP, which in turn must be adopted by the local legislative authority and approved by Ecology. State law requires comprehensive solid waste management plans to be updated at least every 5 years, and more often if changed conditions warrant an update[6].

Counties typically have primary responsibility for preparing comprehensive solid waste management plans. Cities may opt for inclusion in the plan of the county in which they are located, or may develop their own plan. A few Washington cities, including the City of Seattle, have elected to prepare independent plans, and to coordinate their solid waste programs with their county's via interlocal agreement. Under state law, counties have the right to designate the disposal site for all wastes collected within the unincorporated areas of their jurisdiction. Cities have similar authority for wastes generated within their boundaries, but usually assign this authority to the county in whose comprehensive plan they participate by interlocal agreement.

In 1989, the "Waste Not Washington Act" amended Washington's solid waste planning requirements to establish waste reduction and recycling as the first and second solid waste management priorities[7]. The Act established a statewide waste reduction and recycling goal of 50 percent, and mandated source separation of recyclable materials to be the preferred method of recycling. Under the act, curbside collection of recyclable materials must be provided in urban areas, and drop-off sites mst be provided in rural areas. According to the practice currently established by Ecology, the CSWMP of both the exporting and importing jurisdictions (if both are within the state) must allow for the waste export program, and both must be fully adopted and approved by Ecology before the exporting jurisdiction finally commits itself to an out-of-county disposal option. The adopted CSWMPs must also allow for the development of all facilities needed to carry out the program, including solid waste transfer and transportation facilities. If waste export or import is not included in both plans, a formal CSWMP amendment is required to avoid legal or regulatory challenges that could delay implementation of the waste export program.

Oregon. The State of Oregon has enacted waste reduction and recycling laws that affect both local governments in Oregon and out-of-state jurisdictions exporting waste to a regional landfill in Oregon. Operators of these landfills are prohibited by Oregon statute from accepting waste from any jurisdiction that does not comply with the Recycling and Waste Reduction rules promulgated by the Oregon Department of Environmental Quality[7]. To comply with these rules, exporting jurisdictions must:

- Provide an "opportunity to recycle" to each person in the county.
- Provide a public education and promotion program that gives notice of the opportunity to recycle and that encourages source separation of recyclable material.

Initially, the opportunity to recycle was generally defined to mean that all communities with populations greater than 4,000 must provide at least monthly curbside collection of the following materials: non-ferrous scrap metal, used motor oil, corrugated cardboard and kraft paper, aluminum, container glass, hi-grade office paper, tin cans, and yard debris.

At the close of its recent legislative session, the Oregon legislature passed a comprehensive recycling bill that adopted standards and established goals for many aspects of recycling, including collection, market development, and minimum content.[8] The bill redefined the opportunity to recycle by providing local government a choice of the following eight programs and actions to promote waste minimization and recycling:

- provide residential recycling containers
- provide weekly residential curbside collection of recyclable materials on the same day as garbage collection
- expand recycling education and promotion
- provide for collection of at least four principal recyclable materials from multi-family residential complexes of more than five units
- establish a residential yard debris and composting program
- establish commercial and institutional recycling of source-separated materials for large facilities
- expand recycling depots
- enact recycling incentive rates for garbage collection

Depending on their size, communities must implement a minimum of between three and five of these items by July 1, 1992. By 1995, each local government must meet a numeric waste diversion goal that is outlined in the bill. The goals range from a low of 7 percent for small rural counties, to a high of 45 percent for Portland Metro. If a local government is unsuccessful in meeting its goal, the bill requires the local government to implement two additional waste minimization or recycling items.

In 1989, Oregon enacted a bill that exacts a fee of $2.25 per ton of waste generated outside of Oregon but disposed within the state[9]. Legal challenges to this fee are currently under litigation.

Also in 1989, the Oregon legislature amended an existing statute to require out-of-state jurisdictions disposing of waste at an Oregon landfill to provide an opportunity to recycle similar to that required in a comparable jurisdictions in Oregon. During the 1991 legislative session, the law was amended further to define "out-of-region wastes" as waste generated outside the states of Idaho, Oregon and Washington and those counties in California and Nevada that share a common border with Oregon. The recent amendment allows the Oregon Legislative Assembly to levy an additional disposal fee on out-of-region wastes, and states that if the laws of any out-of-region state prohibit or restrict the disposal of any kind of solid waste within its own boundaries, that prohibition or restriction shall also apply to the disposal of such waste in the State of Oregon.[10].

City and County Recycling Goals

Within the planning guidelines established by their states, the cites and counties that currently export their waste to disposal in another county or state have established their own recycling goals and programs. The current results and targets for each exporting jurisdiction are listed in Table 2.

Table 2
SOLID WASTE EXPORTING COMMUNITY RECYCLING RATES AND DIVERSION GOALS

Exporting Jurisdiction	Estimated Recycling Rate	Year of Estimate	Current Waste Diversion Goal
Portland Metro, OR	32%[11]	1991	45% by 1995 50% by 2000
Seattle, WA	40%[12]	1991	50% by 1993 60% by 1998
Kennewick, WA	19%[13]	1989	n.a.
Snohomish County, WA	26%[13]	1989	50% by 1999
Spokane County, WA	27%[13]	1989	50% by 1995
Clark County, WA	27%[13]	1989	56% by 1995
Pacific County, WA	16%[13]	1989	30% to 40% by 1995

ASSURING WASTE MINIMIZATION IN THE REGIONAL DISPOSAL SYSTEM

As described above, the waste export industry in the Pacific Northwest has developed largely through the privatization of disposal services, as publicly owned and operated landfills have filled or have closed in response to new state environmental regulations. During this process, a variety of institutional factors and contractual arrangements have contributed to the simultaneous growth of aggressive waste minimization and waste export programs in the region.

Institutional Factors

As described in the previous section, Washington cities and counties maintain control over all municipal solid wastes generated in their jurisdictional boundaries. They are empowered to develop their own disposal capacity or to contract competitively with private providers of transportation and disposal services. These powers allow exporting jurisdictions to exercise maximum control over the terms and conditions of their waste disposal contracts.

Washington and Oregon laws and regulations governing solid waste management require local planning authorities to establish aggressive waste reduction and recycling programs. Washington jurisdictions cannot operate regional disposal facilities without approved comprehensive solid waste management plans. To gain approval by the Washington Department of Ecology, the plans of both jurisdictions must provide for the export or import of wastes for disposal. Both plans must provide for required waste minimization programs. Oregon landfills are not permitted to receive waste from out-of-state jurisdictions unless the exporting jurisdiction provides at least the same level of opportunity tot recycle as is required of similar jurisdictions within the state.

Contractual Arrangements

Given their institutional powers and constraints, cities and counties contracting with private operators of regional facilities have employed a variety of contractual terms and conditions to assure that they are able to meet their mandated waste minimization goals within the framework of their waste export program.

Definition of Wastes Included in the Program. Contracts between exporting jurisdictions and regional landfill operators typically define as "acceptable waste" all types of municipal solid wastes that have, in the past, been handled by the contracting jurisdiction. The exporting jurisdiction retains the right to divert waste from delivery to the disposal contractor for nay legal form of reuse, reclamation, or recycling. Contracts have generally been structured to allow for but not to guarantee delivery of yard waste and construction, land clearing, and demolition debris that is composted, recycled, or otherwise reused.

Minimum Quantity Guarantees. The waste export contracts signed in the region to date have generally not been "put or pay" contracts of the sort usually signed for waste-to-energy projects. To assure that local jurisdictions may achieve aggressive waste reduction and recycling goals, the contracts typically have either no minimum tonnage provision or a "bare minimum" tonnage that is likely to be much less than the actual amount delivered to the landfill owner. In Snohomish County's contract with its transportation and disposal provider, the county guarantees a minimum annual tonnage on a put-or-pay basis, but the commitment extends to only about 40 percent of the count's anticipated generation. This guarantee extends for only 7 years to the end of the contract's first term. If the County chooses to exercises its sole discretion to extend the contract to 14 or 21 years, no minimum quantity is guaranteed.[14] This arrangement allow generous room for the achievement of recycling goals in both the short and long terms.

Flow Control. Despite the need to allow for extensive (and somewhat unpredictable) success of waste minimization programs, contracts in the region have generally recognized the contractor's need for assurance that its investment in facilities and equipment is generally consistent with the amount of waste that it will receive. This has usually been accomplished through contractual provisions that require the exporting jurisdiction to obtain and exercise its flow control powers so that most or all waste not diverted from disposal by reuse or recycling is delivered to the waste export contractor. In Washington counties, consistent flow control agreements are made part of the adoption of the county CSWMP by participating cities.

CONCLUSION

Several cities and counties in Washington and Oregon have made significant strides toward achieving ambitious waste reduction and recycling goals, at the same time they have initiated programs for the transportation of non-recyclable wastes to disposal outside of their jurisdictions. Rather than promoting irresponsible waste management policies by relieving local jurisdictions from the burden of developing new disposal capacity within their boundaries, waste export programs have been successfully integrated into waste management systems that place first priority on waste minimization. The assurance that waste export will not somehow undermine waste reduction programs arises from the regulatory constraints placed on local solid waste planners by state environmental agencies, coupled with the powers of the exporting jurisdiction to establish terms and conditions for waste export that support local recycling goals.

There is concern in the Pacific Northwest that federal regulations may allow state or local authorities to prohibit or heavily tax interstate transportation of solid wastes. In various court decisions during the last several years, efforts to ban or to tax unreasonably the movement of materials between states for commercial purposes have been seen as barriers to the free flow of commerce between states, in violation of the Interstate Commerce Act. However, a national movement toward restricting or prohibiting waste export has resulted in legislative attempts to allow states to prohibit importation of solid wastes from other states. The outcome of this movement is uncertain. However, in framing controls that attempt to govern interstate waste shipments, legislators and federal regulators should consider the institutional and regulatory factors that have allowed a carefully controlled waste export industry to thrive in the Pacific Northwest. To do so may help preserve an efficient, environmentally sound, and publicly acceptable solution to the need for landfill capacity.

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BREACHING THE BARRIERS TO MOVING WASTE BY RAIL

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Introduction

Of all the North American business trend forecasts made with great vigor and broad consensus in the last 10 years, probably no prediction remains more unfulfilled as yet than the one proclaiming that municipal solid waste will become a major source of railroad traffic.

This paper examines this subject from three perspectives: first, reviewing briefly the reasons behind optimistic waste-by-rail predictions, predictions still being voiced today (including here) even though infrequently realized as of yet; second, identifying and evaluating the barriers to selection of the rail mode for waste -- that is, why facts have not, so far, followed the forecasts; and finally, describing planned or recently implemented waste-by-rail approaches which were found superior to trucking despite the many barriers rail seemingly faces.

The suggested payoff from appreciation of these points is that advance planning for the possibility of rail use in waste systems can reduce the cost of rail installations significantly. Turning that around, we submit that failure to anticipate and foster conditions which optimize the economics of applying rail technology to municipal solid waste transportation systems can create the perverse result that later retrofit of rail capability is deemed not economic.

A subsidiary but also vital conclusion is that rail should not be preliminarily excluded from consideration for waste service merely because the potential rail haul is thought to be so short that rail use is inherently uneconomic. Three waste-by-rail cases reviewed here involve presumptively "short" railroad distances: two at 20 miles, and one at 30. Length of haul is not the key factor in determining rail feasibility for waste transportation, a point illuminated here by both example and analysis.

The focus here is on municipal solid waste (MSW). While movements of sludge and ash may be well suited to rail haul for the same reasons as is MSW, there are enough differences, particularly in equipment design, that the present scope is limited for purposes of length.

Great Expectations

As a preamble to explaining the high hopes for waste-by-rail, it first should be pointed out that it is an anomaly that MSW has never been an important railroad commodity. Fifty years ago, virtually every factory in North America was located on a railroad or waterway. Only as highways and truck technology improved did trucking become a significant player in intercity North American freight transport. Rail dominance was the norm in the industrial sector.

However, MSW involves factory or industrial by-products to only a very small degree. Because the primary sources of MSW, other than the downstream ash generated by mass burn facilities, are food preparation, office buildings, and residences, and are fragmented among numerous, dispersed generating points, it is necessary to have a system for collecting their offerings. This collection task was uniquely suited to trucks. And as long as the destination, commonly what used to be called the local dump, was quite close to the point of collection, there was no need to consider transferring loads from collection trucks to other vehicles for the line haul.

Thus, the first reason behind many predictions, or at least for their exuberance, of a waste-by-rail revolution was that the target market appeared so large. Because of its historical reliance on trucking to date, MSW is the largest single commodity opportunity today in which railroads can increase their share of the transportation market. To a rail industry buffeted by declining volume and market share almost continuously since World War II, MSW has loomed as a rare chance to experience growth.

That historical perspective also illuminates what has changed over time to make forecasters predict a mode shift for some MSW traffic: as urban areas have spread, MSW systems typically have transitioned to new landfills sited farther from the centers of towns than were the old facilities they replaced. But distance per se is not the key. In many cases, the economics of even truck-based systems have resulted in using one set of vehicles to pick up MSW and bring it to a consolidation point from which (with or without compaction) another set of vehicles takes over the haul to a landfill or mass burn facility. Therein lies the key to rail utility in MSW handling:

> **As soon as the parameters of waste handling system design in any particular case suggest the economy of transferring loads from dedicated collection vehicles into dedicated line haul vehicles, the opportunity to cost-effectively introduce a new line haul transportation mode is dramatically enhanced. It is this need for waste transfer, rather than line haul distance, that most profoundly impacts the competitiveness of the rail mode for MSW handling systems. In other words, once the optimal system in any particular locale is judged to benefit from a separate line haul after transfer out of the vehicles used for MSW collection, then rail's biggest theoretical disadvantage is neutralized and the possible competitiveness of rail line haul emerges even for short distances.**

However, considering history again, another factor has sharpened significantly the attention actually given by municipalities to the potential for waste-by-rail: landfill tipping fees have increased dramatically, and are projected to continue upward as a product of not just decreasing supply and rising demand but also the regulatory aggravation of landfill construction and operating costs. As other costs increase, transportation becomes a smaller piece of the total cost of waste disposal; thus, if increases in the cost of transportation are necessary, as they may be in some cases, to achieve the non-economic benefits of rail use, they tend to be less objectionable because of their lesser significance to total waste system economics.

Finally, there are of course the attributes of MSW as a transportable commodity which are commonly recited as matching MSW well to the rail mode: a low value, heavy bulk commodity available in sufficient quantity to move in trainload lots from few origination points to fewer (and declining) numbers of destinations.

As to non-economic benefits of rail, we shall not dwell on the very real political and environmental forces which have motivated many locales to consider rail use. There is little doubt that, in some cases, rail is being perceived as an attractive option mostly because voters want heavy trucks concentrated on a limited number of highways and not on local streets, and thus that new landfill or resource recovery facility siting approvals are less contentious if rail transport is presented as the primary waste delivery mode.

However, one goal of this paper is to establish the distinct point that rail haul of waste is more than a way to grease the approval of controversial siting decisions. If the economic possibilities of even short haul waste-by-rail are better understood, then hopefully more attention will be given to designing systems which, even if initially reliant totally on trucks, nonetheless also optimize the effectiveness and economy of potential future rail use.

Barriers

As noted at the outset, rail haul of MSW seems to be catching on slowly despite its many appeals. Several barriers, discussed in turn below, have impeded the change to rail: lack of economic rail access to older transfer stations and landfills; outmoded perceptions of rail carriage attributes; the increasing burden of governmental regulation; uncertainty about rail economics; capital requirements; and, equipment technology.

Unsuitability of Existing Facilities. The first barrier reflects the reality that a shift to the rail mode is largely going to come about only in connection with construction of new transfer stations, mass burn facilities, and/or landfills. The existing MSW infrastructure, designed originally to optimize only the economics of using trucks, seldom also provides, by happenstance, economic rail use.

Economic rail use is much more than a matter of merely locating facilities on an existing rail line. Facility and process design features which optimize truck economics can give rise to significant capital expense in the event of facility conversion to rail use. A good example of the impact of optimizing a system for one transportation mode to the prejudice of later adding another mode is the line haul truck loading method commonly used for MSW. Typically, compacting equipment at transfer stations is designed to fill the long box of a truck through an end door.

However, it generally is not economical to use end-loaded rail cars because of the prohibitive cost of switching each car to enable loading and unloading. Thus a mode change may necessitate unexpected replacement of various system components such as compaction equipment and related elements of transfer station design.

Prejudicial Perceptions. The second barrier is more subtle. The infrequent involvement of rail in MSW until the last few years has led to a gulf in language and, to some degree, in perceptions, as between waste-handling authorities and railroads. Put simply, rail-optimized handling of MSW doesn't necessarily look very much like truck-optimized systems. An excellent example is the reliability attributes of the competing modes.

Reliability is a key concern of most waste management systems, understandably so given that trash arrives at transfer stations every day even if line haul and landfill facilities are idle. Such systems simply cannot tolerate late or inoperable trains. Although MSW systems may have some excess capacity built in, generally they are not designed to tolerate a breakdown in the transportation system. Thus, to attract MSW business, railroads must overcome an outmoded but still potent public image of general unreliability and fears that rail service may be inadequate.

Those perceptions remain from a bygone era, as reliability is a little-noticed attribute of many rail operations today. Unfortunately, as all North American waste-by-rail systems are new and, therefore, generally perceived as risky, reliability is being maximized through conservative MSW system design, often supported by a backup truck system -- just in case. Such over-design imposes costs ostensibly on the rail alternative, appearing to make the rail mode seem less attractive than it should or can be.

For example, derailments -- perhaps the archetypal manifestation of rail's perceived unreliability -- in fact occur in only a tiny percentage of North American train movements; those which cause significant train delay or line closure are even more rare. Despite publicity attending an occasionally spectacular derailment, most occur in yard and industry trackage and do not impede through movements. Even a mainline derailment seldom blocks track use for more than 24 hours.

As to other reliability factors, railroads today provide dedicated intermodal service (which is a relevant model for time-sensitive MSW operations) on a consistently high speed basis throughout the country. Conrail operates a large fleet of intermodal trains in the Northeast which arrived within 15 minutes of scheduled time almost 99 percent of the time during calendar year 1990. UPS, the reliable parcel business we all use, purposely constructs its major terminals adjacent to rail intermodal facilities and moves many parcels by rail between its hubs. Auto makers have long incorporated rail movement into "just-in-time" production schedules. Most waste-by-rail opportunities are well suited for dedicated trains, because such movements' regular schedules allow control of turnaround, permit maximum equipment utilization and simplify oversight (that is, monitoring trains instead of individual rail cars).

The Government Hand. Regulation is factor in rail's late arrival on the MSW scene. State and local permits/approvals and other regulatory actions, by delaying construction and increasing the cost of new facilities, have the collateral effect of perpetuating older, truck-reliant systems and impeding the introduction of a new transport mode that the regulating governmental entities in fact might greatly prefer over the status quo.

A particularly ominous, but so far tentative, regulatory attack has been state (and supportive federal) legislation restricting import of waste into a state from others. A slightly less transparent initiative was recently introduced in committee draft reauthorization of the U. S. House of Representatives' "Resource Conservation and Recovery Act", which contained a provision which would allow any state to impose fees on movement of waste across its border. There was no provision in this draft which would limit the import fees so that they could not grow large enough to effectively prohibit interstate MSW movements.

Confusing Economics. The next barrier to the embrace of waste-by-rail technology is the difficulty many analysts have had in identifying and quantifying the economic benefits of this mode. While rail's potential for attractive economics is vaguely understood by most members of the waste industry, and while most observers appreciate that rail's appeal is increasing as tipping fees rise, as landfills decline in number, and as longer hauls become necessary to reach new landfills or mass burn facilities, enough confusion remains about quantifying costs and benefits of rail to muddy the conclusions of many waste-by-rail feasibility studies.

The most difficult aspect of modal cost comparison is predicting the future in a case where short-run economics appear to slightly favor motor carriage in a particular case. Given the recent surge in recycling, for example, should planners be advised to be cautious in predicting MSW volume growth which might accumulate to the scale where rail's advantage is clear?

Furthermore, historical truck costs compared with those of rail in feasibility studies also may be unrepresentative of future levels because of the increasing need to dedicate trucks to MSW use, eliminating backhaul use which previously enhanced truck economics and thereby lowered costs to the MSW system. It would seem imprudent to assume that backhaul will not drop significantly from previous levels, but some feasibility studies accept historical truck rate data which is highly sensitive to assumptions regarding the availability of backhaul.

One especially perverse problem arising from confusion over the economics of MSW rail haul is that rail is not even considered in some cases because of the common, but mistaken, belief that rail could not make sense unless a "long haul", whatever that means, is involved. While any pundit could stipulate a haul too short to logically involve rail transport, the fact is that length of haul generally is but one of the factors that bear upon the comparative economics of rail versus truck.

Specialized, large volume rail hauls of less than 30 miles are not unknown not just for heavy bulk commodities but even for intermodal. Moreover, MSW transportation presents a unique characteristic that modifies conventional considerations of length of haul. As mentioned above, the key stage of MSW system evolution and growth is when the haul to landfill (or mass burn facility) becomes long enough to justify a transfer from optimized collection vehicles to optimized over-the-road vehicles (a process typically involving compaction at the transfer point).

In other words, once some transfer activity has become an embedded cost of the system plan, the otherwise normally clear economic advantage of trucking over rail for the haul to ultimate destination should be called into question and verified. (Whether a transfer is justified or not may turn upon complex analyses of truck size and specialization in the context of distance, time, destination facility design, and whether compaction is intended at the transfer point, all of which can be considered independent of any knowledge of the rail mode. But once transfer is considered appropriate, the rail option should be given the same opportunity to demonstrate its viability as trucking.)

Expensive Facilities. Capital costs also have been a barrier to the shift to waste-by-rail. Even when considering new facilities, rail suffers the apparent disadvantage of a higher investment than required for truck- oriented facilities. This arises in both transfer station design and unloading arrangements at destination facilities.

One example of why rail use causes increased capital costs is that rail-optimized transfer stations must be designed to accommodate one-train-a-day movements, whereas continual loading of trucks, one at a time, can occupy all hours of the day. Another common cause of high capital cost is provision of acceptable railroad grades at otherwise apparently acceptable sites where landfill area is largely located on a hillside well above the elevation of a contiguous rail line .

However, rail should not be ignored as an option just because it may require more up-front capital. Its operating cost advantages can more than justify the higher investment, and must be calculated before prematurely abandoning rail consideration. Moreover, the hesitancy to undertake larger capital investments can be mitigated substantially by offering long term contracts for transportation services.

Equipment. The final major barrier to rapid adoption of waste-by-rail systems is transportation equipment -- rail rolling stock and containers. No conventional rail car types or container designs are suitable for the particular requirements of waste transport. Thus, as waste-by-rail attracted increasing attention in the last decade, one of the initial challenges was to convert existing car types or design a new one. A standard waste-hauling rail car has yet to emerge. This lack of standardization has been a significant factor in slowing railroad penetration of the waste market.

While no standard yet dominates, containers are the most common type of waste haul equipment used today in rail systems. It nonetheless is too soon to preclude experimentation with other car types. Moreover, the nature of waste handling processes and facility siting variables are such that no single equipment design is ideal for all situations.

Thus, locales evaluating waste-by-rail typically suffer added expense and delay, relative to an all-truck proposal, to consider a reasonable range of equipment possibilities. Furthermore, the interrelationship of equipment and transfer facilities design complicates the planning process. Nonetheless, the payoff for these extra efforts can be handsome and must be sought until standardization yields clear economies of scale for a single approach.

Success Stories

Despite the barriers portrayed above, several waste-by-rail movements have been instituted or are planned in North America. These successes against difficult odds demonstrate the potency of the rail alternative for MSW.

The first, in Southeastern Massachusetts, has been operating since June 1989. This movement is unique among all waste-by-rail projects in both equipment (gondolas) and destination (a waste-to-energy facility). A front-end loader places loose MSW into cars at the transfer station; the Bay Colony Railroad moves the cars to destination where they are rotated for unloading. Readily available second-hand boxcars were converted to "poor man" bathtub gondolas by sealing the door openings, reinforcing bulkheads, and creating a removable roof. This car type modification is excellent for dumping MSW into a pit. Rail haul was determined less expensive than truck despite the fact that the rail move is only 20 miles.

A recent and representative example of innovatively combining rail and waste technology is a rail move out of Seattle that started in April 1991. Existing transfer stations were fitted to compact MSW and insert it into containers which are trucked to the rail yard and loaded onto double stack rail cars (containers stacked two-high). A dedicated Union Pacific Railroad train operates every other day (as volume increases it will become a daily movement) to an Oregon landfill 320 miles away. At destination the containers are transferred to trucks which are unloaded at the face of the landfill by a truck tipper. This system was found to be less costly than truck not only to the landfill selected but also compared to trucking the waste to Seattle vicinity landfills.

Another waste-by-rail move that started this year despite several obstacles is from Bergen County, New Jersey to Virginia in containers. While origination is at a rail-sited transfer station, the station originally was designed for boxcar loading and had to be converted to use containers. Upon arrival in Virginia, containers are transferred to truck for a short road haul because the landfill is not rail served. In addition, railcars are handled in regular freight trains instead of dedicated service. Rail use still proved economic in what would seem on the surface to be a inhospitable set of circumstances.

Roanoke County, Virginia has reached a long-term agreement with Norfolk Southern Corporation to move MSW. A new transfer station would load waste into new, large cubic capacity bathtub gondolas for a 30 mile rail haul which includes a new five mile rail line to the landfill. MSW will be unloaded with a rotary dumper and trucked to the face of the landfill. While the rates offered by trucking concerns have proven competitive, projected rail movement cost is reported to be slightly better. Norfolk Southern justified its considerable investment in the project by its ability to amortize up-front expenditures over the 25 year life of the contract.

Montgomery County, Maryland expects to begin construction next year on a new resource recovery facility (RRF) complete with a rail haul from an existing transfer station only 20 miles away. The transfer station will be modified to compact MSW into containers loaded onto double-stack railcars for daily movement to the RRF, at which point gantry cranes will transfer the containers to truck chassis for short transit to the pit.

In Conclusion

Clearly, rail must have something going for it to have been selected in this variety of circumstances, using different approaches, and despite sometimes multiple disadvantages relative to truck. It is particularly striking that so many rail systems are being implemented over what traditionally would have been thought of as short hauls. The careful design of new MSW handling systems to facilitate the economic use of rail deserves serious attention.

PRODUCT LIFE CYCLE
THE BROAD VIEW PERSPECTIVES ON MATERIAL USAGE

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ABSTRACT

Examining the materials' choice for a product by "life cycle analysis" (LCA) is an approach that can minimizes total costs, including social costs such as waste generation. This method looks at the relative costs of alternate materials over the entire life of a product and includes at least five distinct life stages: raw material costs, fabrication costs, installation costs, utility and maintenance costs, and post-use costs. Recently, the U.S. Bureau of Mines used "life cycle analysis" to examine case studies in the building and construction (piping), packaging (beverage containers), and automobile (bumpers) industries. Selection factors that influence material competition for specific product applications were evaluated, including relative cost differences at each stage in the product life cycle. The analysis showed how substitution and recycling can greatly reduce waste and reduce the costs that society must bear. The Bureau study identified cost effective methods and models that will avoid waste and maximize a material's lifetime. Ultimate goals characterize how the use of a material contributes to a sustainable process.

This paper addresses ways to assess why and when substitution occurs, and how we evaluate the long-term implications of increasing reliance on nonrenewable resources in the United States. International trends are presented for developed and developing nations. Information is analysed on material recapture, waste reduction, and ultimate discards to the environment. In addition, data bases and information on the plethora of emerging high technology for advanced materials are discussed.

INTRODUCTION

General Motors decides on plastic rather than aluminum for the body of their first electric car scheduled to be introduced in 1994 -- three major aircraft manufacturers negotiate to purchase 11 thousand tons of newly developed aluminum alloy sheet for parts in Boeing's 777 jetliners -- National Concrete Trade Association earmarks polymer concrete in new "flexible" highways -- what do these have in common? The answer is that each material choice for a product has the potential to reduce waste, extend material life, and minimize the total costs over the life of a product.

Who makes this choice? A recent survey by the editors of Plastics Technology magazine (1) suggests a wide range of decisionmakers. Design engineers used to make most of the material choices; now the responsibility is divided (or shared). Processing or manufacturing/production engineers primarily select the materials to be used in an application. General management and design engineers also have major input into the materials choice process.

Customers and R&D departments also can have a significant influence in choosing materials. As a further complication, nearly 80% of survey respondents said that, at some point, alternative materials are substituted for those called out in the original design specifications.

To choose the one material that will work best at the lowest overall cost, a life cycle cost analysis should be performed that relates primarily to direct costs at various stages of product manufacture or use. Each stage of the product life cycle has different cost components. Many of these components relate directly to the material chosen for the application being studied. Some costs are mostly absorbed by the manufacturer; some by the consumer; some by society at large; and some costs may be passed on to future generations. Not all these costs are necessarily taken into account when materials are chosen for specific applications. Many of the costs are large enough (and different for different materials) that they can affect the choice of which material is most appropriate to the job at hand.

Another major component of the material selection process is performance. Any material that is to be seriously considered for an application must first pass a filter condition: Can it do the job? Then, within the group of materials that offer an acceptable set of performance characteristics, it remains to be determined which is able to do the best job at the lowest total system cost. The value of a higher than necessary level of a particular performance property is often difficult to determine. Sometimes a higher performance property can even be envisioned as detrimental. For example, higher strengths above a specified minimum may cause fabrication problems. Within the group of materials with acceptable levels of the appropriate performance criteria, cost is the primary determinant of material choice for an application.

Sometimes the choice of material will be determined through a mandate to consider social costs. This occurs when legislation sets a standard that can only be met by a particular material or class of materials. All materials applications are subject to a variety of imposed or suggested standards, guidelines, and regulations that are based on engineering data and broad experience. Building and product codes are promulgated at all levels of Government. Also, major materials producing or using industries promulgate standards and guidelines. These codes represent limitations to the design process and will constrain the designer's choice of materials.

Another class of external factors are the health and safety regulations set at various levels of Government. Though engineering may play a part in the setting of these regulations, they are largely based on governmental concerns for protecting the society at large. These rules also constrain the designer in the choice of material. Examples of regulations that are already in force in specific industries include: bans on flammable materials in some furniture and clothing, limits on toxicity in fumes from burning pipes and other construction materials, international banning of chlorofluorocarbons (CFC's), degradable packaging for six-pack rings, deposit/return laws for certain types of containers, and mandates for recyclable materials.

As a Federal agency, the Bureau of Mines through their Information and Analysis Materials Program is taking a broad view, examining all the costs in the materials choice processes, thereby being able to comment on the pluses and minuses of materials waste from a social perspective. In many instances, the marketplace seems to be operating efficiently and materials appear to give greatest benefit to society. However, there will be cases of "market failure" because of costs (e.g., recycling or disposal characteristics, toxicity) that are not accounted for by the decisionmaker. In still other cases, the materials choices will already have been impacted by Government action (e.g., the choice of bumper materials as impacted by the CAFE laws, bans on some packaging materials) and the secondary effects of legislation must be examined to ensure they are in society's best interest.

RECENT TRENDS IN MATERIALS USE

In this paper, materials are defined as all physical goods which are used in the economy for other than fuel or food purposes. Currently, every person in the United States mobilizes ten tons of materials and creates a few tons of wastes per year. A century ago much of our needs were filled by renewable resources such as cotton and lumber. Throughout history, materials have been discovered and introduced into use, and diminished in use as newer, more advanced materials have become available. Moreover, there are numerous shifts occurring in the materials we use to meet our physical needs and to shape our environment. Today, our use is principally from nonrenewables such as metals, industrial minerals, petroleum, and natural gas. This trend is shown in figure 1, which displays values in 1972 constant dollars with deflation indices using a 1983 base year. Use of such limited materials must entail responsible stewardship that addresses such questions as: material use efficiency, environmental loadings, performance, safety, health, and domestic and international economic viability.

Materials trends are measured and interpreted in a variety of ways. The most basic is a straightforward reporting of the amounts of materials used divided among the major markets where they are used. An initial question is why these amounts of materials are used, and what is behind the patterns shown by the trends. If the use of one material is growing faster than another, another question arises: Are these materials in direct competition with each other (for a fixed market), or does an expanding market exist of which one material is able to take advantage more than another?

The high rate of growth in use of new materials over the past several decades has been described as having two major drivers: new markets and substitution. New market growth takes advantage of the unique properties to create new products (artificial hearts, squeezable bottles, etc.).

One approach to quantifying substitution is trend analysis. The objective of trend analysis is to extrapolate trends in the achievement of technical capabilities or market penetration. The fitted curves are generally presumed to be linear logarithmic or S-shaped curves (i.e., a slow start, exponential growth, and then leveling off against natural or imposed limits). Another possibility is an "envelope" of multiple S curves where the recognized process is a succession of new technologies maintaining progress toward a fundamental capability.

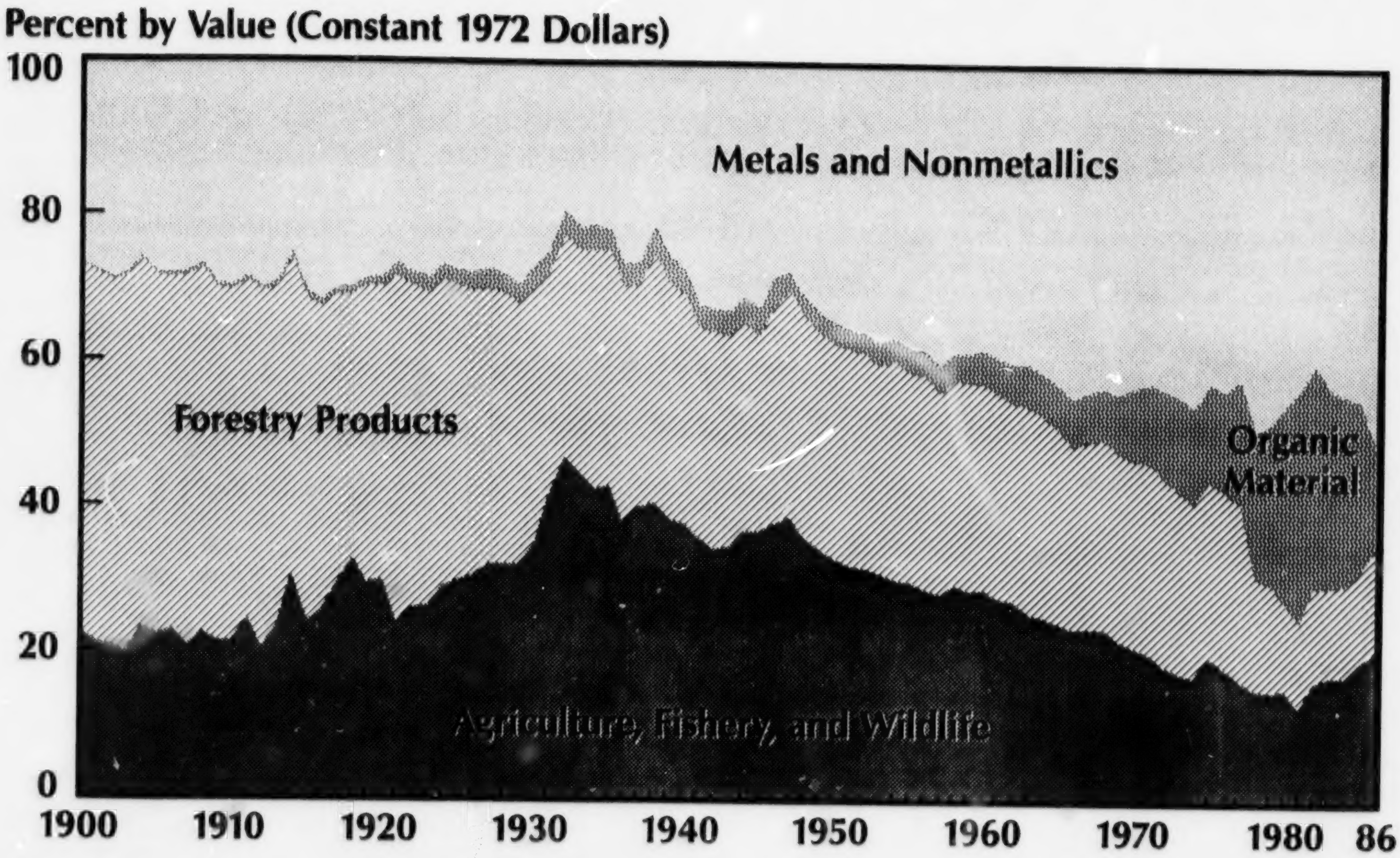


Figure 1 –U.S. consumption of raw materials, nonfood and nonfuel uses

Substitution happens in a specific market when newer materials offer advantages over traditional materials. In appliances, metals offered durability over wood, and plastics enhanced this with lighter weight and rust resistance as shown in this appliance panorama at "A Material World," Smithsonian Institution. (Bureau of Mines photo.)

One specific approach to trend extrapolation is called "substitution theory." A basic assumption of this technique is that if a new technology (or material) begins to replace an existing technology (or material) without a major change in function, the replacement will tend to go to completion, and the time frame over which substitution occurs can be predicted (2). For example, pipe is a market with a material substitution process underway. Figure 2 shows an analysis of plastic pentration in the pipe market.

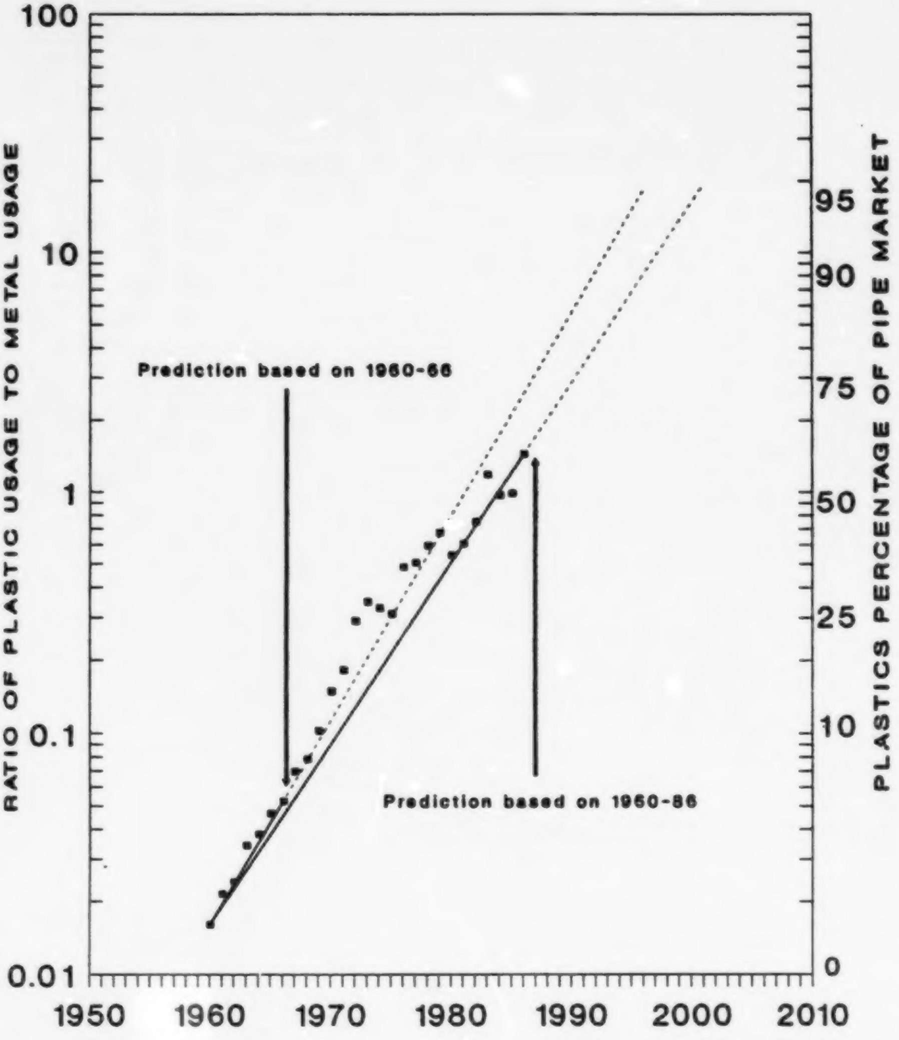


Figure 2 .–Analysis of plastic penetration in the pipe market

The left vertical axis is a logarithmic scale of the ratio of the total plastics used for pipe to total metals used for pipe. The right vertical axis shows the percentage of the pipe market that is plastic. The horizontal scale is time. Substitution theory suggests the ratio plot will be a straight line; it is close.

The values up through 1966 (when plastics accounted for 5% of the market) were used to predict eventual takeover from other materials. The prediction, shown by the dashed line, indicates a 50% takeover in 1981 and a 95% takeover in 1996. As shown in figure 2, the year in which plastics actually exceeded 50% of the market was 1983, only 2 years later than predicted. The expected date when plastics will have 95% of the pipe market was then refined using additional data for consumption through 1986. The 95% takeover date becomes 2000, shown by the extension of the solid line in figure 2. This date is 4 years later, but still close to the year predicted using only data where plastics had just 5% of the pipe market (20 years earlier).

Many simplifying assumptions are implicit in this type of analysis. For example, steel still dominates in some market niches because there are no lower cost alternative materials that can do the job required. A projection like that shown by the trend line, therefore, assumes continual evolution of plastics technology and materials at a rate that makes substitution possible. While certainly possible, decisions based on trend analysis alone would be imprudent.

Another popular form of trend extrapolation is the Product Life cycle curve used to describe the market penetration, growth and decline of products, retail institutions, and even specific outlets. This model relates to Innovation Theory or, more correctly, the theory of diffusion of an innovation through the market (3). A recent article by Waddell and Labys (4) provides a survey of work related to product life cycle theory. The authors give numerous examples of how the time path of materials consumption and the intensity of use appears to conform to a relatively simple S-shaped growth curve with a decline stage. They use this close conformance between the historical data and the mathematical functional form to argue persuasively that trends in materials usage are better characterized as long run shifts between materials instead of simply a reduced usage of materials.

LIFE CYCLE ANALYSES: CASE STUDY APPLICATIONS

Material selection factors are driven by end-use requirements. When only one material can satisfy performance requirements, the availability and cost of that raw material from different suppliers are all that must be looked at. Development of alternative materials with adequate mechanical properties provides the opportunity to trade manufacturing cost savings for material cost savings, thus reducing the overall cost of production. Assessing such tradeoffs requires integrating analysis of material supply with analysis of fabrication and use considerations. The studies presented in this paper focus on key material shifts in specific applications within the major industrial sectors of construction, packaging, and transportation. A case study for each industry sector identifies a market where polymers, metals, and nonmetallics compete for selection. The case studies selected are pipe in construction, beverage containers in packaging, and automobile bumpers in transportation.

In the analysis, the costs associated with each material is determined over the entire life of a product, and includes at least five distinct life stages: raw material costs, fabrication costs, installation costs, utility and maintenance costs, and post-use costs. The life cycle approach for cost analysis identifies which costs are of major importance in material selection.

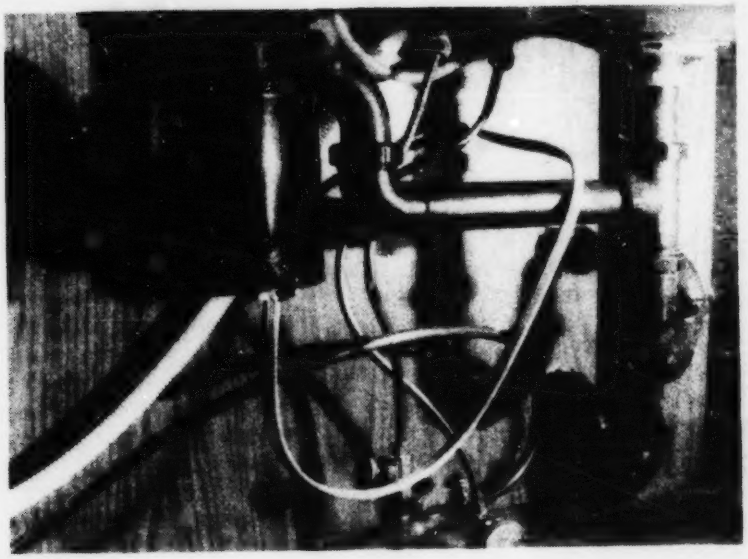
Some of the ways in which these selection factors can influence material competition are illustrated in this paper by examining the relative cost differences in detail for specific applications at each stage in the materials life cycle. These illustrations demonstrate that understanding materials competition is a complex process. Given the requirement to examine specific applications, generic solutions are difficult. However, an understanding of the intermaterials competition for major products in key industrial sectors leads to a clearer understanding of the overall dynamics of substitution. The higher value per pound of resin raw material in relation to other commodity resources would generally make this resource uneconomic except for the low-cost methods of manufacturing used to make many plastic products and the perceived higher value in performance and use. Thus, analysis of domestic viability, and competition, both between materials and nations, must reflect the growing importance of these downstream processing and performance stages. Such full life cycle analyses are presented in this paper.

CASE STUDY 1: PIPING

The analysis of material competition in piping applications starts with the raw materials, continues through the life of the material or product, and ends with disposal or recycle. Each product will have life cycle costs specific to it alone, but the general phases can be broken down into the following:

1. Material costs, including raw materials and fabrication.
2. Installation costs, including labor and equipment.
3. Utility-maintenance costs, including all costs necessary for upkeep and repair of the system.
4. Recycle and disposal costs, including recycle credits, scrap value, and landfill or other disposal charges.

The particular application examined is a residential piping, as shown in the photo below. PVC is the material of choice on a total life cycle cost basis.



One intermaterial competition case study examines 3/4-inch pipe in a residential plumbing system. (Bureau of Mines photo.)

This is, in part, because technological changes such as extruder improvements and advances in polymer chemistry, over the past two decades, have reduced production costs for PVC. PVC pipe is less expensive to manufacture than copper or cast iron, and it is competitive with steel. Compared with metals, PVC is considerably lighter in weight and thereby easier to handle, is easier to assemble, has improved flow characteristics, and is resistant to corrosion and vibration. At this time, waste minimization has only a minor part for PVC pipes.

Raw material costs are only 3% of the total life cycle costs for PVC, 5% for steel, and 18% for copper. Also of importance to the overall competition is the fabrication cost advantage of PVC. Over the past 20 years, improvements in processing technology have resulted in a reduction of fabrication costs for PVC of almost 60%, while steel has experienced a fourfold increase, and copper nearly a threefold increase. PVC maintains its cost advantage in installation, maintenance, and repair. In this case, these demands are reflected in a linear foot rather than weight criterion.

CASE STUDY 2: BEVERAGE CONTAINERS

The analysis of material competition in beverage containers considers the raw material through manufacture, sales, and disposal or recycling. A detailed study of this life cycle helps to reveal cost and performance information which can explain some of the complex patterns of use, product interactions, and trends. These diverse patterns are further complicated by legal and regulatory issues that exert artificial controls in certain parts of the life cycle, especially disposal and recycling.

There are dominant markets for both aluminum and plastic in beverage containers. These niches exist because of unique performance characteristics of each material related to wall thickness, potential stacking problems, and carbonation losses.

Design of the plastic beverage container included a stronger bottom than the sidewalls, which aided in stackabiltiy. The bottom is designed to be easily removed during recycle operations. (Photo courtesy of Wellman, Inc.)

These differences are reflected in the cost analysis of each material for two container categories, the 12-oz container and the 1- to 3-L multiserve beverage containers.

Mid-1987 was chosen as the reference date for cost comparisons because, in many instances, it was the most recent period for which the data were available. For the 12-oz size, a comparison of material life cycle costs is shown per pound in table 1, and for each container in figure 3. Figure 3 is presented because the analysis is different when looking at competition on a weight basis and per container basis. For 1 lb of material, only 2 glass containers or 12 steel containers can be made, but for the lighter weight materials, aluminum and plastic, 27 and 21 containers, respectively, can be produced. Recent improvements in thickness control by steel can manufacturers may alter the analysis somewhat since the mid-1987 time frame. The cost for a given stage is defined as the value added for that stage, which includes the actual expense of doing business plus a profit margin. Two options are presented for the postconsumer stage.

Table 1.--Average cost,[1] in cents per pound, for material used in manufacture of 12-oz containers[2], mid-1987

Life cycle stage	Aluminum	Glass	Plastic	Steel
Raw material.....	124.5	3.4	[3]36.0	38.1
Container manufacturing..	86.0	15.6	131.6	45.7
New scrap credit.	(11.0)	(0.2)	(0.0)	(0.0)
Cost to fill.....	W	W	W	W
Cost to distribute.....	1.0	1.0	1.0	1.0
Cost to bottler.....	200.5	19.8	168.6	84.8
Option 1: Recycling				
Credit.....	(23.7)	(4.3)	(0.0)	(4.0)
Total......	176.8	15.5	168.6	80.8
Option 2: Disposal				
Cost.......	2.0	2.0	2.0	2.0
Total......	202.5	21.8	170.6	86.8

[W] Withheld to avoid disclosing company proprietary data.

[1] Cost includes value added plus manufacturer profit for each life cycle phase.

[2] The total cost is different from the manufacturing cost because the latter cost does not include costs from transport to bottler through disposal or recycling.

[3] All raw material costs and all primary material costs are included in this one value.

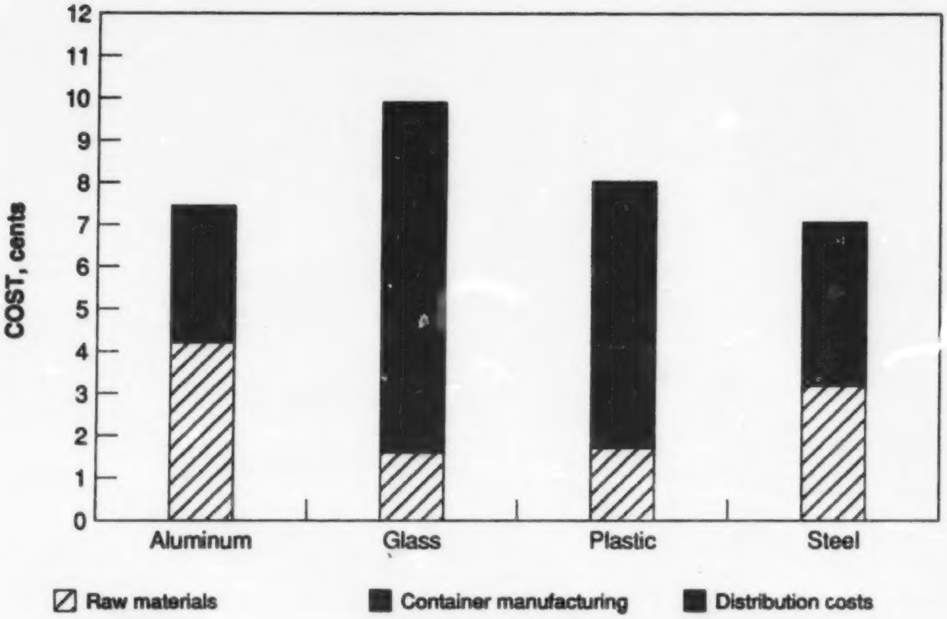


Figure 3 .–Cost to bottler per 12-oz container, mid-1987

One option assumes recycling of the material; where this is occurring, a credit that reduces the total cost is shown. The second option reflects the cost of disposing of the container in a landfill.

Aluminum has the highest raw material cost per pound but less than average costs in terms of price per container. This result is directly related to aluminum's high strength, which allows it to be rolled into very thin sheets with multistep parallel processes: one for the can body, one for the lid. The total apparent cost of aluminum after recycling is the least expensive on a cost per container basis because aluminum has the highest recycling credit. This result is not surprising. Aluminum has a well-developed postconsumer collection infrastructure that is encouraged by the fact that old cans can be recycled into new cans without degradation of the final product. It also has a higher inherent recycle value due to better energy efficiency in reusing this material in a low-temperature melting, fluxing, and casting process, and cold rolling. If aluminum were not recycled but disposed of, eliminating the energy savings, it would bear a higher cost than a comparable steel can.

Glass has the least expensive cost on a per pound basis, but is most expensive on a per container cost. This paradox exists because glass, although extremely plentiful as a raw material, is blow molded in a complex two-step process and is the most expensive to transport from bottler to retailer. Because it is very heavy, much more weight must be carried for the same number of containers. The total cost of glass after recycling reflects the current trend that allows raw glass materials or frits to include in excess of 70% cullet (broken recycled glass), although most bottle manufacturers have used 25%. This ability to recycle greatly improves glass' competitiveness per container. Furthermore, glass beverage containers are available to the manufacturer in either returnable or nonreturnable bottles. Returnable bottles must be more durable than nonreturnable ones; therefore, they are thicker, require more glass per bottle, and are more expensive. At the same time, returnable bottles save costs in terms of recycling because they only need to be washed and sanitized before reuse. Comparing the apparent total cost under option 2, disposal, is a disadvantage for glass once again because of its weight.

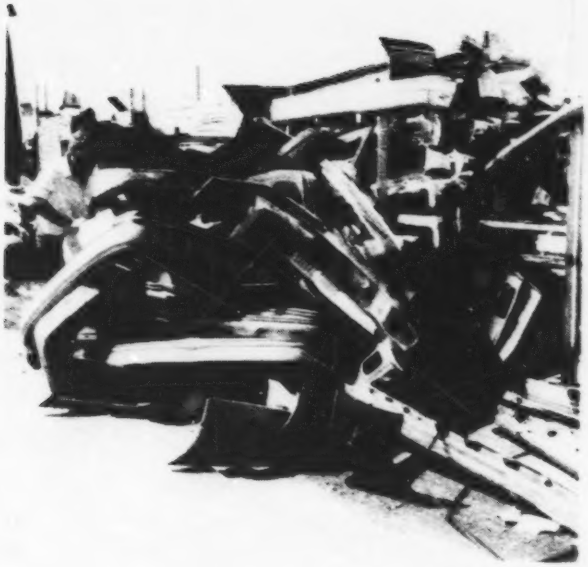
Plastic has a high raw material cost on a per pound basis because of the higher cost for organic feedstock. However, because of its low density and ability to be fabricated with thin walls using less material, cost on a container basis is at the low end of the spectrum. Cost of manufacturing on a per pound or container basis for plastic is high. The high cost is due to the complexity of fabrication that must be done with two different processes: injection molding of a preform and subsequent inflation of the preform by stretch blow molding. Distribution on a weight basis, however, is not costly. Due to its light weight, plastic shares an advantage with aluminum in that they are the least expensive to transport. Recycling gives no advantage to plastic because of its low inherent scrap value. It is less expensive to obtain virgin feedstock than recycled plastic that may be reused only for products of a lesser quality, although new technology announced by Coke and Pepsi show the possibility of closed loop recycling of plastic. Disposal costs are low for plastics simply because, to date, landfill costs are charged on a weight basis and plastic is a low-density material. However, concern over plastic volume in landfills is currently renewing an interest in source reduction and bans of packaging material at the State and local levels.

Steel has the lowest cost to the bottler on a cost-per-container basis, and the second lowest, on a cost-per-weight basis. Steel is comparable to plastic as a raw material on a per pound basis, but because of the amount of metal required per container, steel has a higher cost per container than plastic. Due to similarities in the draw and iron process, mass production of steel and aluminum containers is approximately equal in cost, at the low cost end of container manufacturing. Because of the relatively high value of aluminum scrap, steel becomes the second choice when recycling for both materials is considered at a 100% rate. When disposal at a 100% rate is assumed rather than recycling, aluminum loses its advantage and steel regains its number one position per container.

CASE STUDY 3: AUTOMOBILE BUMPERS

The automobile has numerous parts and a variety of different materials. Thus, it is not possible to study the specific material competition for each part. Rather a specific component system (the Automobile bumper) was chosen to illustrate, for the automobile industry, the life cycle costs of plastic and metal alternatives. Data available for the automobile bumper allow quantification of costs, not only for the raw materials and fabrication, but also for repair, recycling, and disposal.

A 1984 analysis by the Massachusetts Institute of Technology (MIT) (5) looked at the significant criteria influencing the material selection of a bumper component. This analysis occurred at the same time that plastic bumpers were expanding their application in the domestic automobile. This study identified that prior to determining the material of choice, an exclusionary screening was made to ensure that appearance requirements were met and that a minimum performance level of service life, dent resistance, safety impact requirements, and deflection distance were achieved. From among materials meeting appearance and performance requirements, the final selection was made using a tradeoff between low cost and low weight.



Plastics have become the predominant material in the bumper fascia growing from zero to 78% in less than 12 years. (Bureau of Mines photo.)

The MIT study did not consider any of the costs associated with maintenance, repair, direct gas savings due to weight reduction, or disposal. Thus, the study followed the more traditional cost analysis approach taken by a manufacturer rather than a full life cycle cost analysis important to materials policy. The study presented in this paper estimated costs at all the different stages of the bumper life cycle so that the total social cost of each bumper system can be evaluated. These total costs are presented in table 2 for the principal bumper groups.

Table 2.-- The complete life cycle costs of automobile bumper systems (front and rear)
(Net present value)

	Group 1	Group 2		Group 3		Group 4			Group 5	
	All-steel system	Steel beam-Plastic fascia-Steel E/A		Plastic beam-Plastic fascia-Steel E/A		Steel beam-Plastic fascia-Plastic E/A			All-plastic system	
Part components										
Beam................	Steel	Steel	Steel	PC/PBT	PP	Steel	Steel	Steel	PP	SMC
Fascia..............	Steel	Urethane	PP-EPDM	PC/PBT	Urethane	Urethane	Urethane	Poly/ Elast	Urethane	Urethane
Energy absorber (E/A)	Steel	Steel	Steel	Steel	Steel	PE	PP	PE	PE	PP
Cost components										
Material cost.......	46.16	64.46	44.22	94.66	86.68	51.88	57.40	42.44	74.10	71.24
Fabrication cost....	21.36	32.34	27.42	27.24	20.36	40.56	34.92	38.00	28.58	34.46
Fuel cost[1].........	0.00	-13.28	-9.96	-22.92	-18.80	-13.90	-21.80	-26.86	-22.92	-27.34
Low-impact loss costs[2]............	438.45	337.33	406.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Collision damage costs[3].............	0.00	0.00	0.00	180.99	180.99	504.57	504.57	504.57	685.56	685.56
Total costs.........	505.97	420.85	468.53	279.97	269.23	583.11	575.09	558.15	765.32	763.92
Disposal costs (with value of recycled material after use)[4,5].......	-2.21	-1.17	-1.22	-0.13	-0.11	-0.65	-0.69	-0.69	0.47	0.42
Net life cycle cost.	503.76	419.68	467.31	279.84	269.12	582.46	574.40	557.46	765.79	764.34

[1] Based on SAE data - 10-lb weight saving results in 4 gallons over 5 years at 10,000 miles/year. Assume 95 cents/gallon, values reported relative to all-steel weight. All future costs discounted to the present using a real discount rate of 5%. Average life of vehicle assumed to be 10 years.

[2] Assumes one 5-mph collision each 5-year period.

[3] Assumes mid-size car. This is the average annual loss payment increase per insured vehicle year over the lowest cost system.

[4] Assumes recycle credit for steel of $71.83/ton (or 3.6 cents/lb) of steel.

[5] Assumes $25.00/ton landfill cost (1.25 cents/lb) for plastic materials.

Costs associated with collision repairs for high-speed impact are significantly highest for both all-plastic systems as compared to the all-steel system. This comparison reflects the importance of the greater structural integrity associated with the steel beam and the steel energy absorber. As a result, the all-plastic bumper has a higher total cost than the steel system or the mixed system, and the lowest total cost system is a mixed material system with a plastic beam and steel energy absorber. This system was utilized in 1988 on 24% of the passenger cars. These results suggest that as the implications of high-impact repairs become better understood, material selection will continue to favor further penetration of plastics as a reinforcing beam, and the steel stroker energy absorption system should be able to maintain its share of the market as the energy absorber.

This analysis further shows that a majority of the costs associated with the bumper are subsequent to fabrication and become identified only when a full life cycle analysis is made. The lowest total cost system (plastic beam, plastic fascia, steel E/A) has the highest production cost (42% of the total). Other systems have production costs that range from 13% to 19% of the total cost. This calculation means that greater than 80% of the costs associated with these bumper systems involve deferred costs not directly borne by the primary material selector.

This analysis also shows that the major costs associated with the bumper system are beyond those traditionally evaluated in production cost analysis. These additional costs deal with both legislated performance and repair. Analysis of postproduction costs provides a broader understanding of the consequences of the intermaterial competition that is occurring within the industry. A clear indication is seen of the effects that Government legislation can have in automobile design. Without the low-speed impact and fuel-efficiency laws, the plastic bumper would not be nearly as attractive a choice as it is, and the average cost of collision repair for the automobile might not be as high. This choice was not obvious until the life cycle cost analysis was used.

Methodologies that are shown for the bumper system to determine a material cost comparison and market penetration can be applied to other automobile parts or to other end-use applications such as the fuel tank, outer panels, or even some structural components. Such studies allow an understanding, not only of the costs of fabrication, but also material selection, utility measures, and disposal costs. Such studies could be used to influence material selection during the lag time between initial introduction and full-scale market penetration.

CONCLUSIONS

Concepts and results illustrated by these case studies of specific material applications and market segments can be discussed with a more general interpretation. The industry focus for these discussions draw on the life cycle analysis work presented for pipe (as representative of construction), beverage containers (as representative of packaging), and bumpers (as representative of automotive). These three industries, in combination, account for the largest portion of materials use in the U.S. economy.

The discussions of the life cycle analyses have demonstrated the need to look at differences in fabrication costs when evaluating which materials are likely to have the least cost overall. Another consideration is the way in which materials properties relate to processing, especially for new materials (synthetic polymers), where the process can significantly influence the properties of the finished part. The properties of a product made from synthetic polymers will be determined by the parameters of the fabrication process. Consequently, the same material processed at different temperatures, pressures, or flow rates will have different performance characteristics.

The materials selection process involves two distinct but interrelated design aspects: selection of a material and selection of the process by which the material will be formed into the required part. Although this interrelationship has always been true for the designer (materials engineer), the problem of making a wise design choice has been made more complicated with the availability of the wide variety of new materials to select from and the difficulty of cross-comparing data from different sources. More than 10,000 grades of polymers, alloys, and blends are available to a designer, with thousands of new grades being added each year (7). More than 500 new grades of engineering thermoplastics were introduced in the United States in the 1980's (8).

All of the industries examined in this paper (construction, transportation, and packaging) are arenas of intense competition between traditional materials like metals, wood, glass, paper, and the newer materials like plastics. The three previous case studies examined the situation in a large segment of each of those markets. Material uses, trends, and patterns were presented with explanations as to why they were occurring, with special reference to relative cost and performance. Pipe was cost driven material substitution. Beverage containers were cost plus performance driven substitution. Automobile bumpers were cost plus performance plus legislative mandate driven, i.e. CAFE laws, substitution.

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PERCEPTION VERSUS REALITY

PERCEPTION

A letter to the editor of the London Free Press recently from a noted environmental activist alerted society to the coming horrors of privatization of waste management in the southwestern Ontario counties of Middlesex and Elgin where my brother and I run a group of modest waste management facilities. The fear seems to be that those in the private waste management sector cannot be trusted to perform the necessary role without ripping off society. In the article the writer and university professor, Ms. Rhonda Hustler uses the activities of one of our competitors, Laidlaw Waste Systems to complain that it has doubled its Landfill fees to dispose of waste from Strathroy, Ontario a town of just over 10,000 West of London, Ontario and that by 1994 the rate will be a gouging $60.00 a ton. Mrs. Hustler obviously doesn't know that the most famous gouger of all is Metro Toronto. That bastion of public ownership charges in excess of $150/ton to get rid of its waste stream. Metro Toronto is also trying to force through "flow control" which would require every producer and/or hauler of waste to pass through Metro's " Cash Cow" Transfer facilities. And you thought state ownership, communism and all was dead and buried in Eastern Europe - heck no it's just moved to Ontario -

Ms. Hustler isn't aware of the longstanding offer to sell our facilities, recycling plant and all to the appropriate government authorities for their independently appraised value.

I'd be happy to leave this industry and enter one with a proven record of achievement under privatization. MAIL DELIVERY!

Ms. Hustler's usual modus operandi is to attack the environmental shortcomings of any site expansion she tackles. Since none exist at Green Lane - the obvious alternative is to play the old Public Sector Ownership Saw.

There was never any legitimate concern about our business operations until it came time to extend our landfill. The opposition came out of the woodwork.

A local group, opposing the site, was formed, incorporated to avoid responsibility for statements made by individual members and the attack started.

"The wells are all polluted"

"Those guys don't recycle anything at all - they just put everything in the dump - charge high rates and pocket the profit"

"They dump liquid, hazardous wastes in the middle of the night - I've seen the trucks"

"They dump liquid waste all the time - their certificate doesn't allow that!"

"Why I've seen leachate running right out the sides of the site, into the Hunt Drain down to Turkey Creek through the Oneidas of the Thames, First Nations lands and into the Thames River."

"They're only talking about recycling now because they want to expand - any effort they make is too little - too late!

"There's no protection from ground water pollution - they'll just take the money and run."

REALITY

The reality, however is somewhat different than that posed.

The site is safe - There is not one single shred of evidence that any leachate has ever migrated from the site - the perimeter leachate collection system is working as predicted. Leachate has never flowed out of the sides of the site through the heavy clay soils which, for those with a technical background have a porosity of K-7.

From exhaustive, on going analysis of water wells throughout the area no well has ever indicated any pollution from the landfill site - Perimeter test wells confirm the findings.

There is an Environmental Trust Fund in place - these funds, which with irrevocable letters of credit, stand at just under $200 thousand, and growing with every tonne of waste landfilled, are in the hands of the Ministry of the Environment. They are available to address any pollution problems caused by the site.

No hazardous or liquid waste is received at the site - Pakmore and Truxmore both use a cylindrically-shaped truck and the untrained eye can make an error.

Any liquid waste vacuum trucks at the site bring sand from car washes or the distillate from a nearby corn refinery plant that makes ~~Nutrasweet~~.a natural sugar calorie-low sweetner.

None-the-less, the campaign by the opponents of the site has had its desired effect. One of their best moves has been to enlist the support of the nearby Oneidas of the Thames

Indian Band. The young chief and his council are feeling the rush of victory in their newly recognized constitutional voice and the environment is high on their hit list. No matter that our company at their request some 10 years ago went on the Reserve, helped to close and clean up a really bad site and have since accepted their own waste stream at a modest $8/yd.

Recently our sanitary landfill was ordered to close because the licensed capacity of the site had been reached. Only the intercession of the Minister of the Environment, the Hon. Ruth Grier could have averted the emergency. The emergency designation was rejected. There was an alternative site available - 100 km. to the West near Chatham, Ontario the Ridge Landfill Corporation, owned by B.F.I. is licensed to accept waste from the four Counties of Essex, Kent, Elgin and Middlesex.

B.F.I. presently has its own application before the MOE to increase not only its service area but its yearly capacity as well. You see two other sites in South Western Ontario are slated to close within the next 16 mths: And they have capacity problems of their own to face. Interestingly enough B.F.I. is being permitted to file its service area extension application under the old Environmental Protection Act. All people are equal but some, it seems to the M.O.E., are more equal than others.

The increased costs of disposal coupled with annually transporting some 75,000 tons of waste will cost the taxpayers of St. Thomas alone as much as one million dollars more per year than present. A further one million dollars per year will be borne by the constituent municipalities of rural Elgin County and Industry and Commerce will incur yet another million dollars per year in costs for the disposal of its waste stream.

Notwithstanding a vigorous 3R's program throughout the service area of Green Lane Landfill an administrative paper shuffle has been allowed to bring us to this sad state.
DELAY IS THE CRUELEST FORM OF DENIAL

Green Lane Landfill, a fully engineered site, under the supervision of Conestoga-Rovers and Associates, was approved and opened in June of 1978 with a licensed capacity of 650,000 tons. It was estimated that it would reach capacity after 12 or 13 years. Their are 270 Zoned Acres for landfill on the original 320 Acre holding while the first footprint of 70 Acres has some 30-32 acres filled to date, a further 500 Acres ± held either by ownership or long-term lease with first right of refusal to purchase, serve to buffer the site.

In 1982 the County of Oxford in tow with the local office of the MOE approached Green Lane officials to inquire as to the availability of its capacity to accommodate Oxford County and its County seat, the City of Woodstock. MOE officials indicated that an emergency certificate would be issued to Oxford County and the site contours of Green Lane were suitably adjusted to accommodate the increased waste volumes by up to three and half million cu. yds. and still leave Green Lane with its original 12-13 years of operating capacity.

Oxford County purchased three 96 cu. yd. transfer trailers and sent a purchase order for disposal to Green Lane. As all of this was happening the existing site in Norwich Twp., owned and operated by Laidlaw abruptly closed. The president of Laidlaw at the time Neil Dietweiler called local MOE officials and said, "We're full, and the site is closing today at 5:00 P.M." While there was obviously more capacity at the site MOE officials asked to meet with Mr. Deitweiler the following week and a meeting date was arranged.

When extra capacity was indicated visually to Mr. Deitweiler he indicated that they were full - not that the site was necessarily full but that the company was full - right up to here and they were all done.

Oxford County let its waste sit on the curb for a couple of weeks while they hastily concluded arrangements to buy the site from Laidlaw and continued to operate the site, environmentally out of compliance certainly by today's standards, until after a long and protracted hearing the Salford site was eventually approved and opened in 1985.

Oxford County waste never did come to Green Lane which had been operating at the new contours in the interim. When the ultimate decision on Oxford and Green Lane was finally arrived at, MOE officials unilaterally collapsed the original footprint at Green Lane to keep it in compliance with the original 650,000 ton license. They obviously didn't want Green Lane Landfill to last too long. It was good enough to accommodate Oxford but not too much of its own waste stream!

The three 96 Cu. Yd. Transfer trailers still sit in Oxford County's equipment terminal. They're for sale and at $30,000 a copy they're a good buy. Perhaps the MOE should buy them and make them available to the some 24 landfills that are continuing to operate out of compliance.

Surprised are you? Twenty four landfill sites that are presently operating out of compliance - that's hard to believe. Not really when you examine how the Ministry operates. They selectively turn a blind eye to those sites that they deem to be either ones which cannot be addressed or too small to worry about. There's still lots of little dumps that continue to burn and leach on an ongoing basis.

Others, like Green Lane are simply out of administrative compliance.

Most however are out of environmental compliance.
[fill in details of the worst environmental problems on half dozen or so]

As President of Green Lane Landfill I have been charged with an offence under the Environmental Assessment Act with fines and a suitable jail term in the offing.

We have appealed to the courts - Quite simply a judge should hear the evidence including the whole sordid mess of the MOE's bureaucratic night mare.

There's a sign making the rounds these day throughout Industry and Commerce and it goes something like this. "Bad planning on your part doesn't create an automatic emergency on Mine." We're the exception to the rule and it would seem that if you're in Private Enterprise in the waste business your turn will come as well. Bad planning on the government's part can and does create an emergency on yours.

In 1988 officials of Green Lane visited with MOE officials in Toronto, noting that the site would be at capacity in about 3 years and outlined their plans for expansion under the existing Environmental Protection Act. Municipalities operated under the more stringent Environmental Assessment Act but Private industry was not at that time included. More than a year later Green Lane officials received a letter from the MOE stating that notwithstanding the work done to date for expansion under the EPA Green Lane would now be under the Environmental Assessment Act.

With just over 2 years of capacity left Green Lane was faced with a 7 year process. Despite our best efforts to speed the Waste Management Study now under way to establish new long term capacity either at Green Lane or another preferred location we are still another 2.5 years from completion of that process.

Since the MOE announced its original 4R's program the shareholders of Green Lane have taken the following steps to meet the Ministry's goals for Ontario's environment.

Established two of the largest corrugated recovery operations in Southwestern Ontario. One at the Ford Assembly plant in St. Thomas and the other at Recycle London Inc. a newly completed facility opened just one year ago on the Wellington Road South of London.

Recycle London Inc., in partnership with Sonoco Limited has a large office fine paper recovery program. Both Paper

Savers and Schaefer 96 gallon Carts are supplied to participating customers. The fine paper is brought to Recycle London, graded, baled and shipped to receivers.

As well,the standard fare of blue box receipts including glass, cans, plastic bottles, newspapers as well as household corrugated, boxboard etc. are received at the facility for separation and processing with some of the most modern equipment in the industry.

Southwestern Ontario, with its eight automobile plants, where up until a few years ago only four existed, has a huge surplus of wooden pallets. These pallets are received at Recycle London where they are shredded, the nails removed by magnet, supplied to feed lots and poultry facilities where they serve as bedding for animals. The manure inoculates the wood chips which are then available for composting with other organic wastes from grocery stores, restaurants, clubs and household kitchen wastes. Everything is in place to establish the composting facility except the MOE permit. Once again paper shuffling has held up what would otherwise be one of the preferred processes by a responsible Private Waste industry to Ontario's Environmental Revolution.

Perception Versus Reality - You be the Judge!

PRIVATE SECTOR APPLICATION UNDER THE ENVIRONMENTAL ASSESSMENT ACT: A Case Study

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Abstract

A Draft Joint Submission for approval under the Environmental Assessment Act and Environmental Protection Act is expected to be submitted in 1991 by Domtar Fine Papers, Pulp and Paper Mill, Cornwall, Ontario. A summary of the application process will be presented at this conference. The waste management concept to be submitted is a landfill combined with 3R's initiatives. The site selected for landfill is within the City of Cornwall.

Domtar began investigating the need for a new landfill in the mid 1980's, with the objective to submit an application under the Environmental Protection Act (which includes the environmental impact study of the selected site). Presently in Ontario, private sector landfills are not explicitly subject to the Environmental Assessment Act (which includes a rigorous evaluation of need, alternatives, site selection, and public participation in addition to the work required by the Environmental Protection Act). This paper will discuss the rationale behind the decision to voluntarily be subjected to both the Environmental Assessment Act and Environmental Protection Act. Differences between the planning processes and their implications for the outcome will be discussed. To add to the level of uncertainty, there are no guidelines or specific requirements for private sector Environmental Assessments and, to date, no private sector landfill undertakings have been submitted for approval under the Environmental Assessment Act.

The challenges for undertaking a private sector Environmental Assessment are presented to illustrate the perceptions and realities involved in the following areas:

- the Private sector and the applicability of the EA Act,
- siting,
- role of the 3R's,
- criteria development and the role of the public, and
- public consultation.

Introduction

This paper is intended to provide an overview of the application of an environmental assessment planning process to a private sector industrial waste management problem. A case study of the mill residue management strategy proposed by Domtar Inc. is presented. A summary of the reason for the project is followed by a discussion of the approvals required in Ontario. A discussion of the challenges of applying the EA process, which is primarily designed for public sector projects, to a private sector undertaking is followed by the conclusions of the paper which discuss the benefits of the EA process to the private sector.

A Draft Joint Submission for approval under the *Environmental Assessment Act* and *Environmental Protection Act* is being prepared by Domtar Specialty Fine Papers, Pulp and Paper Mill, Cornwall, Ontario. The waste management concept to be submitted for approval is a landfill combined with 3R's initiatives. The site selected for landfill is within the City of Cornwall.

At the time this paper was written, the Draft Environmental Assessment was under internal review by the proponent, Domtar Specialty Fine Papers. The Environmental Assessment had not yet been submitted to the Ministry of Environment. For this reason, some details of the EA are not included in this paper.

The Private Sector Proponent

Domtar Inc. is a resource-based corporation engaged in the manufacture and marketing of a wide range of products. The Fine Papers Division is one of four operating sectors within the Domtar Pulp and Paper Products Group.

The Cornwall Mill is one of the company's four fine grade paper operations and is one of the largest fine grade paper mills in Canada. The mill's yearly production capacity is rated at 270,000 short tons of fine paper. This includes over 500 different grades of paper in a variety of colours, finishes, weights, and sizes which are shipped to markets throughout the world.

The mill is located on a 125 acre site on the banks of the St. Lawrence River. The site was selected in 1881 with the first sheet of paper being produced in 1883. The mill came under Domtar ownership in 1962 when the corporation was established.

The mill has expanded from employing 324 people in 1920 to a current number of approximately 1,450 employees. More than 90% of the wood purchased (273,000 tons) comes from local woodlot owners. The mill operates six paper machines and an off machine coater to give the mill a total daily capacity of 870 tons.

The Project

Domtar Fine Papers, Cornwall Mill proposes to develop and operate a landfill facility for the disposal of mill residues. In addition to the development of this facility, Domtar will enhance in-house 3R's activities at the Cornwall Mill and undertake one or more of the following:

- clarifier sludge recycling;
- composting; and
- bark selling as fuel to divert residue from landfill.

The landfill facility in combination with these diversion 3R's activities constitutes the Domtar undertaking.

Mill residues will be transported from the Cornwall Mill and disposed of at a state-of-the-art engineered landfill. The site selected for the landfill facility is located in the northwest section of the City of Cornwall, south of Highway 401 and west of Brookdale Avenue (Highway 138).

The landfill area will be 27.6 ha in size and within a 59 ha land parcel.

The anticipated capacity will allow for mill residue management for approximately 20 years.

Rationale for proceeding with the undertaking include the following which were determined during the EA process:

- Current waste management disposal of mill residue occurs at an onsite landfill. This landfill is nearing capacity.

- Methods of mill residue management other than landfilling were considered. Methods of reduction and diversion were identified and included in the proposal; however, some mill residue still requires disposal.

- Several disposal technologies were considered and landfilling was seen to be the preferred method.

Approval Requirements

Approval for the Domtar facility will be sought under the *Environmental Assessment Act* of Ontario, the *Environmental Protection Act* of Ontario, and the *Planning Act* of Ontario. There are also several other statutes, regulations, and policies and guidelines which affect the planning development and approval of the proposed Domtar facility.

The Domtar undertaking is, by law, subject to the requirements of the *EPA* and Planning Acts. As a private proponent, Domtar is not automatically subject to the *EA Act*.

Environmental Assessment Act, 1980

The *Environmental Assessment Act* is an Ontario Statute administered by the Minister of the Environment. It was passed in 1975 and made applicable to municipalities as of 1980. The *Act* provides for the assessment of the potential effects on the environment of a proposed undertaking and its alternatives. This *Act* differs from other pieces of environmental legislation in that it sets out an environmental planning process rather than a regulatory process. The planning process set out by the *Environmental Assessment Act* essentially involves the definition of the alternatives that could achieve a desired purpose, and a progressive narrowing down of these alternatives based on the study of the environment to be affected and the effects of the various alternatives on the environment.

The intent of the *Act* is to require proponents of undertakings to consider, in the early stages of planning, the alternative means of achieving a desired goal, the likely environmental effects of those alternatives, and the actions that may be necessary to prevent, remedy or mitigate those effects. In addition, although there is no legislative requirement for pre-submission public consultation, it is generally understood that - within the intent of the *Act* - proponents should consult with the public, government reviewers and potentially concerned parties during the planning process if an adequate assessment of an undertaking is to be accomplished.

The *Environmental Assessment Act* applies to all public undertakings by the Government of Ontario and its agencies, including municipalities. Private sector undertakings are subject to the *Act* only if they are designated as such by regulation.

Environmental Protection Act, 1980

The *Environmental Protection Act* is an Ontario Statute administered by the Minister of the Environment. It sets out the prohibitions related to the deposit, addition, emission or discharge of contaminants into the natural environment. The scope of the environment covered by the requirements of this *Act* is not as broad and all inclusive as that covered by the *Environmental Assessment Act*. It provides the mandate for the Ministry to issue control orders or stop orders related to contaminated sources. It also establishes the powers and procedures used by the Minister, Director and Ministry of the Environment staff in the regulation and control of contaminant discharges. These include the requirements for certificates of approval and program approvals, the power to make regulations related to various causes of contaminants, the power to prosecute and/or impose fines upon offenders, and the requirements for public hearings. Part V of the *Act* (which is currently being revised) sets out the specific interpretations, prohibitions and requirements related to waste management.

This *Act* applies to any existing or potential sources of contaminant and any persons - in the private or public sector - who are responsible for such sources. In the case of most public undertakings and some private undertakings, the requirements of the *Environmental Assessment Act* would have to be met before the requirements of the *Environmental Protection Act* would be applied.

Planning Act

The *Act* is an Ontario Statute administered by the Minister of Municipal Affairs and Housing. The *Act* addresses a wide range of issues pertaining to public planning. Some sections of the *Act* have a bearing on the establishment of the proposed facility, specifically sections which address proposed industrial uses and their conformity with official plans.

Submission Under the EA Act

The Domtar undertaking is not currently subject to the *EA Act*; however, the Ministry of Environment staff suggested that if the undertaking was submitted only under the *EPA*, an EA would be recommended due to the controversy surrounding waste management projects.

Since EA is an up front planning activity, it seemed prudent to submit a joint application, rather than attempting to back track or start over to complete the EA after the *EPA* application had been submitted. It was seen that a joint application would maximize the opportunity of success for the application.

Domtar's initial proposal to manage its mill residue was to develop a landfill facility at a Domtar owned site. Given the controversial nature of waste management type problems, Domtar recognized the need for a rigorous planning process and public input. The outcome of planning the facility in accordance with the requirements of the *EA Act* was that different (additional) alternatives were examined, additional and intensive 3R's programs were initiated, and a different preferred landfill site was identified as a result of a more comprehensive site selection process.

Private Sector Application Under the EA Act - Challenges and Benefits

There are several challenges to face when applying the EA process to a private sector undertaking:

1. The Private Sector and the Applicability of the *EA Act*.

Although private sector landfills are not subject to the *EA Act* by regulation, in practice, the MOE in Ontario is recommending that private sector landfill projects adhere to the *EA Act*. It is anticipated that the *Act* will be modified to reflect MOE's position.

Because no private landfill applications have yet been presented to the EA Board, there are no standards to follow. Adjustments to the *EA Act* and guidelines are required to reflect the differences in the jurisdiction, decision-making, values and flexibility of the private proponent.

2. Siting

Siting of waste management facilities is usually a difficult and contentious process.

Site selection is different for private proponents because they do not have the option of expropriation. Properties owned by the proponent, or available for purchase by the proponent limit the search for the most environmentally suitable facility site. It cannot be assumed that an environmentally suitable site will always be available for purchase. The element of "lands available" for purchase introduces the concept of "affordability" for the private proponent in the face of land price speculation and cost considerations.

In the case of Domtar in Cornwall, the site selection process was successful in identifying the preferred landfill site in a location that optimizes the planning criteria for environmental attributes. Domtar has acquired an option to purchase the site. Despite following a rigorous planning procedure for site selection, a public opposition group has been formed: PALS (People Against Landfill Sites). This is expected with facilities of this nature. Despite initiatives taken, public opposition is likely to arise when trade-offs have to be made, and everyone cannot be satisfied.

Through the public consultation process, a resolution of the concerns raised by PALS is being attempted. At the time this paper was submitted, meetings to discuss issues were still ongoing.

3. Role of 3R's

In Ontario and elsewhere in Canada, the key to managing non-hazardous waste is thought to be the 3R's. Demonstration that alternative methods, including 3R's initiatives, have been examined is very important to the success of waste management EA's.

The 3R's include reduction, reuse and recycling. For the public sector, these initiatives apply to post consumer products. The concept of "post consumer products" does not apply to private industry waste management problems.

The application of 3R's to a municipal system where no diversion initiatives have been previously used is relatively straightforward.

Often for private sector proponents, some 3R's are part of their normal production and good operating practices. The quantification of waste diversion due to these efforts is less obvious than for the private sector.

The greatest problem is a matter of definition. What practices are actually 3R's? There are no formal guidelines to define the requirements for the private sector or in fact what constitutes 3R's. For example, it is normal practice for Domtar to "recycle" fine paper trim and rejects back into the paper making process. Does this indicate a waste diversion practice? It does not qualify as a "recycled paper" because no post-consumer fibre is used. Similar problems of definition arise when considering fibre recovery from the clarifier, and bark diversion. These commonly practiced methods of waste management do not fall easily within the definitions of 3R's but should be recognized as waste diversion.

While public sector projects make an attempt to identify suitable markets for materials collected in their 3R's programs, the markets for private sector 3R's initiatives must be appropriate from a business perspective. This limits the number of initiatives available to the private sector.

4. Criteria Development and the Role of the Public

Criteria for the selection of alternatives are selected with input from the public and through the public consultation process.

The reality is that this is the private sector. Good business practices must be taken into consideration. Profit is a consideration. The criteria set by consultants and the public cannot be such that they will put the proponent out of business.

The concept of providing a suitable waste management facility at an economic cost must be considered in the private sector. Long term business strategies must also be considered.

5. Public Consultation

The atmosphere of public consultation is different for a private proponent than for a public proponent. Often the proponent will seem to be always on the "defensive". It could be that public consultation is more dificult for the private sector as the need for the facility can be perceived as being for the private sector with no benefit for the public. Since the facility is not seen as a public facility, the issue of how much the public "trusts" the proponent may arise.

Domtar was very successful in setting up a Public Liaison Committee which brought interested members of the public together with the industry staff responsile for the planning process of the waste management project.

Is There a Benefit to Environmental Assessments in the Private Sector?

There are substantial cost and time requirements for submitting an environmental assessment.

The environmental assessment procedure subjects the private sector to a very open public process; which may not be the norm for them.

Some of the benefits of EA from the private perspective include:

- the full evaluation of all feasible alternatives allowing the identification of the best solution;
- although it may be more costly initially, the preferred option will likely result in fewer problems in the long run;
- the EA allows for long range planning (i.e. no short term solutions for long range problems);
- following the EA process is more likely to provide a project that is more acceptable to the public and thus less controversial, resulting in easier implementation; and
- following the EA process may help the corporate image.

Conclusion

As we stated during the introduction to this paper, this EA is still in the draft stage, and no other private sector landfills have been presented to the Ontario Environmental Assessment Board. While we are confident in a positive resolution of this waste management problem, the proof, and approvals, are yet to come.

Despite the concerns we have outlined regarding the EA process for the private sector, there are a few thoughts we would like to end with based on our experience with this application:

- The environmental assessment process forces a thorough evaluation of alternative methods, both technical components and sites for facilities. We believe that in the case of this application, an improved undertaking and site have been identified, while recognizing business issues.
- For the pulp and paper industry, there is a problem with the definition of what practices fall within the definition of 3R's, and indeed what the requirement may be.
- Proceeding with an environmental assessment in the private sector results in a 2 way education process. The private sector has to become used to dealing with the public in a way which the public can provide input to the decision making; and the public must learn to appreciate the business aspects of a private company.
- More private sector projects will likely be subject to the *EA Act* in the near future.

PUBLIC PERCEPTION OF HEALTH RISKS

Gaining Public Acceptance for a Project First Requires an Understanding of the Basis for NIMBY

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Introduction

The fundamental reason for widespread NIMBY opposition to waste disposal facilities is the gap between the perceived health risks of such facilities and the actual health risks presented by their operation. Risk communication specialists have long known that the same risks that frighten people are often not the same risks that kill people. Paradoxically, most people believe life to be riskier today than it was in the past, and that they will face even greater risk in the future, while professional risk assessors hold that just the opposite is occurring. Factors that cause people to overestimate health risks include whether the risk is poorly understood and the effects uncertain, whether the risk is assumed voluntarily or is imposed by others, how close to home the risk is located, and whether the risk occurs naturally or is manmade. The failure of health risks to be properly communicated has resulted in people not knowing when to demand action and when to calm down because the health risks are trivial or simply not there.

The notion that inaccurate perceptions of risk contribute to NIMBY-type opposition has enormous implications for waste management officials seeking public acceptance of a project. First, it is important that the public become involved in the process in the form of citizen advisory committees or similar organizations. The committee must be involved at the outset of the process in order to develop trust in the individuals performing the risk assessment. Second, the results of a risk assessment must be brought into focus rather than presenting them as an incomprehensible list of risk probabilities. Figures can be brought to life through comparisons with other everyday risks such as radon contamination and comparisons with other disposal options. Third, risk assessment results must be described to the media in terms that laymen can understand.

What do we mean by "Risk"?

Risk is an aggregate concept that is frequently expressed as the likelihood of an event occurring -- such as death or disability -- in a large population, over some unit of time.[1] Risk should be calculated from an objective standard. Generally, experts make their assessments of risk by breaking down the event into components until each part is taken as a whole. The measure of risk for each separate part is then added to the other parts to obtain the resultant measure of risk for the original action or event.[2] In making these assessments, experts have access to information about hazards that lay persons lack.[3] Therefore, the experts can make accurate assessments of the potential hazards that face society. They are then able to realize, for example, that eating a peanut butter sandwich may pose as much of a risk to public health as living near a resource recovery facility.[4]

The public, however, lacks the tools to gather and analyze the technical aspects of certain hazards. Therefore, their perception of risk is often very different from that of the expert. Ordinary citizens can only analyze information about a potential hazard based upon their own knowledge of that hazard and their own experience. There are about two dozen factors that go into public evaluation of a hazard. The top six are: (1) Magnitude: people are more concerned with major accidents that cause multiple fatalities in a single stroke than a condition that causes the same number of fatalities over a period of time; (2) Evidence: poorly understood, or scientifically unproven technologies produce heightened level of concern; (3) Personal Choice: voluntary risks are more acceptable than those imposed by others; (4) Not In My Back Yard: a risk that is closer to home is more upsetting than widespread risks shared by the general public; (5) Publicity: media attention heightens concern, regardless of the numbers involved; (6) Source: man-made hazards are less acceptable than natural ones.[5] Although this list is not exhaustive, it is a good indicator of how the general public perceives risk. Often, the public will calculate risk from outrage and an instinct to survive. Unfortunately, lack of knowledge of the danger involved can give people a false sense of security or a false sense of fear.

Experts, on the other hand, pay no attention to the subjective criteria listed above. They are only concerned with the hazard.[6] Experts may take raw data and apply it to the following equation: Risk = Probability x Severity. Or, in more complex situations, they may use the equation: Risk = Probability x Severity x Weight. In the latter equation, the weight factor is necessary to determine that risks of apparently similar magnitude may be accorded different weights in consideration of the totality.[7] In other words, the possibility of two similar, major accidents might have a high risk factor of many deaths. However, the actual possibility of them occurring might be higher for one based on some other variable and thus the probability has increased, producing a riskier venture.

Some experts maintain that the public has lost contact with reality in terms of understanding risk. For example, according to one physicist, the public's understanding of radiation dangers has virtually lost all contact with the actual dangers as understood by scientists.[8] Also, since the risks of nuclear power are unknown, and the perceived consequences are uncontrollable, inequitable, catastrophic and might affect future generations, people seem to ignore the fact that few people have actually died as a result of this technology.[9] As stated above, lay people sometimes lack certain information about hazards. However, their basic conceptualization of risk is much richer than that of the experts and reflects legitimate concerns that are typically omitted from expert assessment. Thus, in trying to communicate the actual risk potential, the expert must be willing to understand and empathize with the public's concerns. The public, for its part, must be willing to understand and learn the truth about new technology.

Communicating Risk to the Public

It is important for companies involved in large-scale public works to be able to communicate to the public the appropriate level of danger associated with their activity. Understatement can often be as counterproductive as overstatement. Understatement can lead, as it already has, to charges of attempts to whitewash the public. Insufficient concern for the public's reaction to a proposal or adopting a patronizing attitude can lead to a loss of credibility. For example, solid waste is a foreign subject to most people. The average person has a generalized notion that solid waste is a bad thing, but is not truly familiar with the risks associated with its management. Therefore, since the public is unfamiliar with the various technologies, especially resource recovery, they fear that some operational error or planning miscalculation might have severe consequences. Since the media has devoted a lot of time to the subject, the public assumes that a high level of risk is involved. In response, citizens will fight the company or government that proposes a new waste management method because they fear for themselves and for future generations. In this situation, it becomes clear that government and industry must make a concerted effort to educate the public about what is involved in various waste management techniques and what the inherent risks are for each. In doing this, the industry should be able to relax some of the fears that the public may have and continue to address the real-world problems the industry faces.

How does the industry transmit to the public the true risks involved? First, it is important to note that the public generally does not trust non-public entities that have an economic interest in whatever it is they are trying to advocate.

Second, the public is usually unfamiliar with the processes involved, even though it will often react to subjective connotations of the process. It is important that the effort be organized in a positive, educational fashion; too often situations are reactive and organized so as to place the project proponents in a defensive rather than offensive position.

Third, any organized effort by a government agency to educate the public will often recognize goals such as "correcting misperception", "educating the public", "reducing conflict", "easing implementation", or "increasing legitimacy". On the other hand, the public tends to approach this effort by trying to reach a goal such as "safe disposal of solid waste".[10] If the agency is to ever achieve public acceptance and credibility, it must express its goals as means to achieving the ends for which the public is searching, not as means to achieving its own goals.

Fourth, the agency cannot afford to wait until the project has reached its final stages before it engages in public disclosure and public participation.[11] The public needs to feel that a good faith effort has been made to reach out and obtain their input before the major decisions are made. The best method is usually to appoint a citizen advisory group or similar body, composed at least in part of technically-oriented people such as engineers and scientists. This can also be regarded as another means of educating the public by taking the advisory group through the thought process of the agency.

Fifth, given the public's limited understanding of the concept of risk, programs for risk communications should (1) be treated as research problems for which limited knowledge base now exists, (2) involve the use of diverse mechanisms for any given set of program objectives, (3) employ control groups wherever possible, and (4) undergo rigorous evaluation.

When educating the public about these risks, the public should be made aware that there are no zero-risk solutions, that tradeoffs are necessary and that uncertainty cannot be avoided.[12] In order to make the risk assessment analysis more comprehensive to the public, the agency might consider: (1) improving the presentation of risks and analyses by avoiding technical and bureaucratic language; (2) casting the results of risk analyses in terms that make sense to lay people and that allow them to learn and gain experiences with the information; and (3) improving the interaction with information transmitters, like science writers, community leaders, and members of the media. Apparently, the most pressing is the need for improving the presentation of risk information.[13] The public needs to hear the problems and the analyses in ordinary language that they can understand and use, in a constructive way, to determine their own safety.

In conclusion, the public has a great misunderstanding of what is risky and what is not. Most of this misunderstanding comes from a lack of knowledge and a lack of trust. They are unfamiliar with the issues and they do not trust faceless governmental agencies or large corporations, each of which may seem to have goals inconsistent with those of the public. Therefore, the public tends to react to concepts without any understanding of what they are trying the achieve. When citizens react in this manner, they may create more danger for themselves, and may also compromise the pursuit of rational problem-solving.

It is the responsibility of the governmental agency to educate the public on the actual events or actions and their true meaning in terms of public safety. Any risk communication program should carefully spell out communication objectives and list alternative strategies for achieving them. The basis for doing this is to determine the objectives of lay people, educate them in ordinary language and to encourage the public to take personal risk reduction measures. Risk communication will benefit from more explicit criticism of inconsistencies and logical traps built into some of the legal framework for risk regulation.[14]

Footnotes

[1] Health Education Research - Editorial Kenneth R. McLeroy.

[2] Crouch, A.C.E. & Wilson, R., Risk Benefit Analysis, Ballinger Publishing, 1982, p. 9.

[3] Id.

[4] Peanut butter contains Aflatoxin B, a cancer causing agent which is more harmful than the effect of ingesting dioxin emissions from a resource recovery facility, day in and day out, at the maximum impact, for seventy years. Kenneth A. Ralph, PhD., URI Center for Atmospheric Chemistry Studies, from a report on the effect of emissions (Chart).

[5] Risk v. Reality, How the Public Perceives Health Hazards, Christine Russell, Washington Post, June 14, 1988.

[6] Id., p. 17.

[7] Risk/Benefit Analysis, Crouch & Wilson.

[8] Id.

[9] Id.

[10] Six Propositions on Public Participation and their Relevance for Risk Communication, Roger Kasperson (1986).

[11] Id.

[12] Improving Risk Communication, Ralph L. Keeney and Delof von Winterfeldt (1986).

[13] Id.

[14] Id.

RISK ASSESSMENT:
IT'S NOT REALLY BLACK MAGIC

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INTRODUCTION

Quantitative risk assessment is the process of estimating the likelihood and/or severity of adverse outcomes to individuals and populations. In general, "risk" has a very broad definition – "risk" can indicate a risk of deaths from an airplane accident, the risk of damage to an aquatic ecosystem, risk of development of cancer following an exposure to a chemical carcinogen, etc. This article focuses on the quantitative assessment of human health risks due to exposure to chemicals in the environment.

Risk management is the process of choosing among policy alternatives based on evaluation of the risks, economic, social, and political concerns. Risk management typically consists of the following steps: (1) identifying a situation that might pose a risk, (2) quantitatively assessing the risks present, (3) deciding what level of risks are acceptable, and (4) taking action to limit or manage the risks present so as not to exceed the acceptable risk level. Thus, risk assessment is merely a tool in the risk management process. We must emphasize that the process of identifying an "acceptable" risk level is separate from the process of quantifying risks. To the extent possible, a quantitative risk assessment should assess the risks present for a given set of circumstances independent of judgments concerning acceptable risk levels.

In 1983, a committee was assembled by the National Academy of Sciences to provide a framework for the performance of risk assessments. As outlined by the committee (NAS 1983), quantitative risk assessment consists of four steps:

- Hazard Identification – The determination that a particular chemical is causally linked to particular health effects;
- Toxicity Evaluation – The determination of the relationship between magnitude of exposure and the probability of the occurrence of health effects (also referred to as "dose-response assessment");

- Exposure Assessment – Identification of scenarios of possible human exposures to the chemicals of concern, and quantitative estimation of those potential exposures; and
- Risk Characterization – Combination of the exposure and toxicity evaluations to characterize potential risks, including identification of the uncertainties inherent in the risk assessment.

In the United States, the first two steps – hazard identification and toxicity evaluation – are performed by the U.S. Environmental Protection Agency (U.S. EPA). The Agency has performed numerous assessments of the toxicity of various chemicals, largely relying on data generated from animal studies and bioassays. These toxicity assessments may be updated by U.S. EPA as more data become available. The fourth step, risk characterization, involves simple calculations to estimate the likelihood of potential adverse human health impacts. Of the four steps in quantitative risk assessment, exposure assessment contains the greatest variability and subjective elements. Consequently, most of the developments regarding risk assessment methodology and practice have focused on exposure assessment.

EXAMPLES OF RISK ASSESSMENT APPLICATIONS

The application of risk assessment methodology in the regulatory process has recently gained momentum in the United States. Several agencies, including the Food and Drug Administration, Occupational Safety and Health Administration, and the Environmental Protection Agency, apply the methodology to establish standards. Unfortunately, there is not a standard process across agencies for making exposure assessments or determining acceptable risks. Even within the U.S. EPA, there is only limited coordination in establishing exposure assumptions and acceptable risk levels. Despite this lack of continuity among programs, U.S. EPA applies risk assessment methodology in the development of regulatory thresholds, in the remediation of hazardous waste sites, and in establishing emission and discharge limits for facility permits.

Development of Regulatory Thresholds. Two examples of the use of risk assessment in development of regulatory thresholds are the programs established within the Clean Water Act and the new Clean Air Act. U.S. EPA uses risk assessments to set drinking water standards, known as Maximum Contaminant Levels (MCLs). The acceptable risk level used in the water program is often 10^{-6}. The Agency has sometimes proposed a risk level of zero for compounds known to be human carcinogens.

The United States Congress re-authorized the Clean Air Act last year and explicitly incorporated the concept of risk assessment within its mandate to U.S. EPA. The Act requires the Agency to establish emission levels for industrial sources based on the maximum achievable control technology. Congress also mandated that, after this technology is implemented at an industrial facility, residual risks associated with continued emissions of contaminants must be determined. If these risks are found to be unacceptable, then further pollution control measures will be required.

Remediation of Contamination. Baseline risk assessments are used to determine the extent and magnitude of contamination at Superfund hazardous waste sites. The results of these assessments are then used to identify remediation options. The available remediation options are evaluated and ranked using a number of criteria, including the level of risk to public health and the environment posed by the use of a particular remediation technology.

The Agency has also applied risk assessment methodology within the RCRA Corrective Action program. The goal is to make RCRA and Superfund remediation activities as comparable as possible. Action levels (defined as levels of contaminants that trigger further action under program requirements) are established using risk assessment methodology. A facility owner/operator can either accept the action level and proceed to take corrective action or the owner/operator may conduct a full site risk assessment to determine whether remediation is actually necessary. For example, at one industrial site, contaminant concentrations in soils were found to exceed action levels, but the results from a site-specific risk assessment demonstrated negligible risks to industrial employees.

Discharge and Emission Levels in Permits. Finally, risk assessment has gained acceptance as a decision-making tool in the permitting process within RCRA and will likely be incorporated in air emission permits under the Clean Air Act. With publication of new regulations for hazardous waste incinerators, boilers and industrial furnaces, risk assessment was given as an option for setting emission levels at individual facilities. The Agency used risk assessment methodology to establish screening levels for different pollutants. In addition, facility owner/operators can conduct a separate risk assessment to identify site-specific emission levels for metals. Given the different conditions across individual sites, most owner/operators choose to conduct their own risk assessments to develop site-specific standards.

Risk assessment will be required in determining the level of residual risk remaining after implementation of the maximum achievable control technology under the Clean Air Act. Whether the risk assessment will be conducted by U.S. EPA or the facility owner has not yet been determined. However, it is likely that individual facility owner/operators would want to conduct the risk assessments as a check of any decisions made by U.S. EPA.

U.S. EPA POLICY AND GUIDANCE FOR RISK ASSESSMENT

The National Oil and Hazardous Substances Pollution Contingency Plan, or NCP, (U.S. EPA 1990), which is U.S. EPA's policy statement for implementing the Superfund program, was updated in 1990. The NCP requires all exposure assessments to be based on estimates of reasonable maximum exposures (RMEs). The preamble to the NCP states that "only potential exposures that are likely to occur will be included in the assessment of exposures ...." and "[the RME is] designed to include all exposures that can be reasonably expected to occur, but does not focus on worst-case exposure assumptions" (U.S. EPA 1990).

U.S. EPA has published several guidance documents concerning exposure assessment methodology as part of the implementation of the NCP. In October 1989, Risk Assessment Guidance for Superfund (U.S. EPA 1989a) was published and released. This document, referred to as "RAGS," comprises the Agency's most complete and current recommendations for performing exposure and risk assessments at Superfund sites. The recommended methodology for exposure assessment under RAGS focuses on estimating an RME. RAGS defines the RME as "the highest exposure that is reasonably expected to occur at a site," and states that "the intent of the RME is to estimate a conservative exposure case that is still within the range of possible exposures" (U.S. EPA 1989a).

Previously, exposure assessments for Superfund sites generally included both average and upper-bound exposure estimates. The advantage to this approach is that the range of exposures provided a measure of the uncertainty associated with the exposure assessments. However, U.S. EPA has concluded that the disadvantage with the two case approach was that the upper-bound estimate may be above the range of possible exposures while the average estimate may be lower than exposures experienced by much of the population. Consequently, U.S. EPA currently endorses the RME approach for use in exposure assessment.

RAGS covers the entire risk assessment process in the context of Remedial Investigation/Feasibility Studies performed within the Superfund program. Although RAGS was prepared specifically for use in Superfund, the principals and methodology recommended in it are also being implemented in risk assessments performed under other U.S. EPA programs, such as RCRA, and in other agencies. The main refinements in RAGS over previous guidance documents relate to exposure assessment. These refinements include:

- Expanded discussions of exposure pathways;
- Inclusion of equations to estimate exposures via these pathways;
- Recommended values for exposure variables in these equations to estimate a reasonable maximum exposure, as well as sources to consult for additional values; and
- Recommended use of the 95th percentile upper confidence limit on the arithmetic average as the assumed exposure concentration for exposure assessment.

Chapter Six in RAGS provides guidance for estimating an RME and identifies exposure variable values appropriate for use in estimating an RME.

In 1989, the U.S. EPA published the Exposure Factors Handbook (U.S. EPA 1989b). This document discusses the sources of information that U.S. EPA reviewed in their efforts to recommend values for exposure assumptions. The Handbook is a source of reference material for estimating age-specific values for exposure variables. The major exposure variables discussed are: drinking water consumption rates, consumption rates of vegetables and fish, inadvertent ingestion of soil, inhalation rate, skin surface area, body weight, and life expectancy. The Handbook also presents formulae for estimating exposures via various pathways.

In addition, in March, 1991, U.S. EPA published supplemental guidance to RAGS entitled "Standard Default Exposure Factors" (U.S. EPA 1991a). This guidance was created by an intra-agency workgroup that was charged with recommending default values for use in exposure assessments. The purpose of these default values is to reduce "unwarranted variability" among exposure assumptions used in Superfund risk assessments. The default values recommended in this document supersede those in RAGS and should be used unless site-specific values can be justified. Pathways covered in this guidance include ingestion of drinking water, ingestion of soil and dust, inhalation, consumption of homegrown vegetables, and consumption of locally caught fish. Unfortunately, recommended values for dermal exposures are not provided.

A review draft version of the Interim Guidance for Dermal Exposure Assessment (U.S. EPA 1991b) is currently in circulation for comments. As a draft, this document does not constitute Agency policy, but it does provide an indication of the direction that U.S. EPA will take with regard to dermal exposure assessment. Specifically, this document discusses ways of estimating dermal absorption of chemicals and summarizes default values for variables such as skin area available for contact and dermal adherence factors for soil. When finalized, this document will serve as a companion to the "Standard Default Exposure Factors" (U.S. EPA 1991a).

ELEMENTS OF HAZARD IDENTIFICATION AND TOXICITY EVALUATION

As noted above, the hazard identification and toxicity evaluation steps in the risk assessment process have been largely completed under the regulatory programs in place at U.S. EPA. Hazard identification often consists solely of examining the chemicals regulated under the applicable program(s), for instance, the Clean Water Act or the Superfund program, and comparing that list with the list of chemicals present at the site or situation in question. In theory, this process could result in ignoring the presence of other possibly hazardous components, but in practice, most of the chemicals that can pose real risks in environmental situations have been included under one or more of the applicable regulatory programs.

Toxicity evaluation has been performed in a quantitative manner for a large number of chemicals. U.S. EPA has established quantitative dose-response evaluations for hundreds of chemicals (carcinogens and non-carcinogens) in its Health Effects Assessment Summary Tables. The derivation of these toxicity values follows set Agency procedures for carcinogens and non-carcinogens.

Carcinogens. The quantitative estimate of the carcinogenic potential of a chemical per unit dose is termed the "slope factor" or SF. SFs estimated by U.S. EPA are generally based on animal bioassays conducted at doses that are much higher than those encountered by humans in the environment. The animal responses at these high doses are extrapolated to low doses using a linear model; the SF is calculated by taking the upper 95th percentile confidence limit on the potency estimate from this model. Thus, SFs include a number of highly conservative assumptions, and may greatly overstate the actual risk posed by a chemical. U.S. EPA readily admits the potential overestimation of risks from the use of this model, but justifies the conservatism on the basis of being protective of human health.

Non-Carcinogens. U.S. EPA has assigned "Reference Doses" (RfDs) to chemicals which have health effects of concern other than cancer. These RfDs are used by U.S. EPA to express the daily intake level of a constituent below which non-carcinogenic health effects are not likely to be observed. This process is based on the assumption that non-carcinogenic effects will exhibit a threshold dose below which effects are unlikely to be observed. Regulators review toxicology and human health effects literature for dose-response information, identify a "No Observed Adverse Effects Level" or a "Lowest Observed Adverse Effects Level" (NOAEL or LOAEL), and use safety factors on the identified dose level to estimate a "safe" daily exposure level for humans. For example, if a study in rats showed a NOAEL at a dose of 1 μg/kg/day for liver enlargement, the EPA would be likely to apply a safety factor of 10 to account for interspecies differences and an additional safety factor of 10 to account for sensitive individuals. Thus, the estimated reference dose for humans would be 0.01 μg/kg/day. The conservatism in this approach, demonstrated in Table 1, is evident.

TABLE 1. APPLICATION OF SAFETY FACTORS IN ESTIMATING REFERENCE DOSES FOR HUMAN EXPOSURES

No observed adverse effect level from animal study	**1 μg/kg/day**
Safety factor - Interspecies differences	10
Safety factor - Sensitive individuals	10
Reference dose for human exposures	**0.01 μg/kg/day**

ELEMENTS OF EXPOSURE ASSESSMENT

Simply defined, exposure assessment is the "determination or estimation of the magnitude, frequency, duration, and route of exposure" (U.S. EPA 1989a). Thus, the definition of "exposure" itself is important to understanding the exposure assessment process. Exposure is defined as "contact of an organism with a chemical or physical agent" (U.S. EPA 1989a). Exposure is quantified as the amount of the chemical at the skin, lungs or gut of the organism that is available for absorption. But in fact, exposure calculations generally go one step further and account for absorption in order to calculate a biologically available dose. A great deal of uncertainty is associated with exposure assessment – primarily because exposures generally cannot be measured and must be estimated. Exposure estimates require several assumed values for exposure variables that are appropriate for the exposure setting and the population that is likely to be exposed.

The following paragraphs outline the steps involved in performing an exposure assessment. Due to the varying requirements for risk assessments in different regulatory contexts – e.g., permitting, remedial clean-up, etc. – not all of these steps are necessary in all risk assessments.

Environmental Sampling and Analysis. The issue of environmental sampling is central to performing accurate risk assessments because the concentrations of the contaminants are central to the entire process. Sampling can be conducted following one of three strategies (Keith 1990):

- Judgmental – Sample collection is concentrated in areas thought to be contaminated;
- Systematic – Samples are collected at specified points in a grid that is overlaid on the site; and
- Random – Samples are collected completely at random at a site.

The choice among these sampling strategies is largely a matter of economics and accuracy. For example, judgmental sampling requires the least number of samples, but introduces the greatest bias in estimating representative concentrations. Conversely, random sampling introduces the least amount of bias, but requires the largest number of samples. Consequently, most risk assessments for hazardous waste sites use systematic sampling strategies with modifications to include extra samples in areas of greatest concern.

Selection of Chemicals of Concern. A risk assessment could include an almost limitless list of chemicals for evaluation. In practice, however, the utility of a risk assessment is limited if too many chemicals are considered. Thus, there exists a trade-off between producing meaningful results with a characteristic set of chemical contaminants and a performing calculations for the complete list of contaminants.

Information about the site or situation in question can be used to make initial restrictions on the universe of chemicals to be considered. For example, if the site in question was a solvent tank farm, then metals and pesticides may not need to be included. Further restrictions can be made if the risk assessment is being performed under a regulatory mandate that considers a specified list of chemicals, such as the priority pollutants under the Clean Water Act. Finally, site- or situation-specific data can provide further basis for eliminating chemicals from consideration. In the case of a hazardous waste site, sampling data can be evaluated and chemicals that fall into categories such as the following can generally be eliminated from further consideration without changing the results of the risk assessment:

- Chemicals that were not detected in sampling, or were detected infrequently at "moderate" or "low" levels.
- Naturally occurring chemicals, such as metals, that do not occur in excess of average "background" levels for the area.
- Chemicals that were associated with blank sample contamination.

This process should result in a list of chemicals of concern for the site or situation. In some cases, different chemicals of concern will be identified for each of the environmental media (soil, ground water, air). For example, when exposures to both soil and ground water are being evaluated at a site, chemicals with limited solubility in water may not be of concern in ground water, but they may be of concern in soil.

Representative Concentrations. The next step in an exposure assessment is determining representative concentrations of all chemicals in all media with which receptors are likely to come into contact. Current U.S. EPA guidance recommends use of the 95th percentile upper confidence limit on the arithmetic average concentration. Rather than being a simple straightforward process, determining representative concentrations can be quite complex. First, the analytical data must be examined. Limits of detection, such as the "instrument detection limit" and the "practical quantitation limit," influence estimation of representative concentrations. It is common practice to assume that contaminants are present at levels equal to one-half of the limit of detection for all "non-detects" to estimate representative concentrations for risk assessment.

In addition to measured concentrations, it is often necessary to estimate concentrations of contaminants in various media. For example, resuspension of contaminated soil can result in airborne dust particles that can be inhaled, and contaminants in subsurface soils have the potential to leach into ground water. If direct measurements are not available, mathematical models and methods can be used to estimate unknown or unmeasurable quantities.

Exposure Pathways. The next step is to define the potential receptors at a site and the pathways by which they might be exposed to the chemicals. Potential receptor groups can include residents, industrial/commercial employees, agricultural employees, and recreational users. Commonly evaluated exposure pathways include:

- Dermal contact with soil,
- Incidental ingestion of soil,
- Inhalation of dusts and vapors,
- Ingestion of agricultural products or vegetables grown in contaminated soil,

- Ingestion of contaminated drinking water, and
- Ingestion of fish and shellfish caught from contaminated waters.

Estimating Exposures. Exposures are expressed as milligrams of chemical per kilogram of body weight per day (mg/kg/day). The formulas to estimate exposures via all pathways, termed "intakes," are of the general form:

$$\text{Intake (mg/kg/day)} = \frac{(C)(CR)(EF)(ED)}{(BW)(AT)}$$

where:

C	Concentration of the chemical in a specific environmental medium,
CR	Contact rate in units particular to a specific environmental medium,
EF	Exposure frequency (events/year),
ED	Exposure duration (years),
BW	Body weight (kg), and
AT	Averaging time (days).

Intakes of non-carcinogens are averaged over the duration of exposure and are termed "Average Daily Doses" (ADDs). Intakes of carcinogens are averaged over the entire life expectancy, generally assumed to be 70 years, and are referred to as "Lifetime Average Daily Doses" (LADDs). If a chemical has both carcinogenic and noncarcinogenic effects of concern, both an ADD and an LADD are calculated for use in the risk assessment. These different exposure estimation methods are predicated by the Agency's methods of determining toxicity constants (RfDs) and carcinogenic potency factors (SFs).

Appropriate values to use for the various exposure variables depend on the receptor population under consideration. For example, the receptor population might consist of adult and child residents, adult commercial/industrial employees, agricultural employees, or recreational users. With the adoption of the "Reasonable Maximum Exposure" concept, U.S. EPA has devoted substantial effort to collecting information regarding these exposure variables and recommending default values for use in risk assessment. Currently recommended default values for residential and industrial populations are compared in Table 2. As these values are merely default assumptions, it is likely that site-specific information or data can be used to justify values that more accurately reflect local site use conditions. U.S. EPA guidance allows for the use of reasonable and justifiable values applied with professional judgement for exposure variables.

TABLE 2. COMPARISON OF DEFAULT EXPOSURE ASSUMPTIONS (a)

Exposure Variable	Residential Receptors	Industrial Receptors
Body Weight	Adults - 70 kg Children - 15 kg	70 kg
Exposure Frequency	350 days/yr	250 days/yr
Exposure Duration	30 years	25 years
Averaging Time for Exposure	70 yr (Carcinogens) 30 yr (Non-carcinogens)	70 yr (Carcinogens) 30 yr (Non-carcinogens)
Soil Ingestion Rate	Adults - 100 mg/d Children - 200 mg/d	50 mg/d
Inhalation Rate	Adults - 20 m^3/day	20 m^3/8-hr day
Drinking Water Ingestion Rate	Adults - 2 L/day	1 L/day
Soil Dermal Adherence Factor (b)	1.0 mg/cm^2	1.0 mg/cm^2
Exposed Skin Surface Area (b)	Adults - 5,000 cm^2 Children - 2,500 cm2	5,000 cm^2

(a) U.S. EPA 1991a
(b) U.S. EPA 1991b

RISK CHARACTERIZATION

Risk characterization involves the combination of the exposure assessment with toxicity information. Potential carcinogenic effects are estimated as the probability that an individual will develop cancer over a lifetime as a result of exposure to a given chemical. Potential non-carcinogenic effects are characterized by comparing estimated daily intakes of compounds to reference doses, which can be thought of as maximum acceptable daily intakes.

Carcinogenic Risk Estimation. Carcinogenic risk is quantified as the probability that exposure to a given dose of a chemical over a lifetime will result in cancer. Carcinogenic risk is estimated by multiplying the lifetime average daily dose (LADD) for a chemical by the slope factor established by U.S. EPA:

$$\text{Risk} = (\text{LADD})(\text{SF})$$

Risks associated with exposure to each carcinogen are summed to estimate the total excess carcinogenic risk presented by all chemicals at a site. U.S. EPA considers total carcinogenic risks in the range of 10^{-6} to 10^{-4} to be acceptable (U.S. EPA 1990). Risk levels near the higher end of this range are often considered acceptable for situations involving small populations (Travis et al. 1987), as is often the case with industrial exposures.

Hazard Index. The Hazard Index (H.I.) is defined as the ratio of the average daily dose (ADD) to the reference dose for a given constituent:

$$\text{H.I.} = \text{ADD} / \text{RfD}$$

Following U.S. EPA guidance, the individual Hazard Indices for each constituent of concern are summed to produce a total H.I. for the site. A total Hazard Index below 1.0 is regarded as presenting no increased risk of adverse non-carcinogenic health effects.

Risk Characterization in Standard Setting and Permitting. In the case of setting standards, the above equations are rearranged. An acceptable risk level or Hazard Index is identified and the resulting acceptable daily exposures are calculated. The acceptable daily exposure is then used in conjunction with the exposure equations to identify a corresponding acceptable contaminant concentration in the medium of interest. A similar process can be used in permitting applications to back-calculate acceptable contaminant levels.

UNCERTAINTIES IN RISK ASSESSMENT

The process of exposure assessment is full of uncertainty. Despite the simplicity of the equations and the recommendations by U.S. EPA, there remains a great deal of uncertainty about most of the individual steps and assumptions that go into performing an exposure assessment. The following paragraphs discuss examples of uncertainty in the exposure assessment process, and, where possible, demonstrates the numerical impact that these uncertainties have on final exposure and risk estimates. The risk assessor and/or decision maker must be aware of the uncertainty inherent in this process and should endeavor to discuss all uncertainty that is associated with the results of the risk assessment.

Toxicity Indices. Although the SFs and RfDs used in risk assessment have been derived by U.S. EPA and are probably not subject to modification for a site-specific risk assessment, the many uncertainties inherent in their derivation and the assumptions implicit in their use should be well understood and explained in the risk assessment. As described above, most toxicity indices are extrapolated from animal studies. The basic assumption that effects observed in animals can be extrapolated to humans in a quantitative way, while possibly protective of human health, is not always justifiable on scientific grounds. Differences in metabolism and biology between species sometimes make this assumption highly uncertain; such differences are rarely incorporated into the toxicity evaluation performed by U.S. EPA.

For example, in recent years the applicability of the results of carcinogen bioassays in rats and mice to humans has been questioned. Some common tumors observed in rats and mice in response to chemicals (for example, liver tumors in mice and rats and kidney tumors in rats) are now believed to be largely a species-specific response that may not predict human responses. Nonetheless, these tumors are used in the U.S. EPA determination of carcinogenic slope factors. U.S. EPA may discuss the potential problems with these data in documentation, but the Agency still uses the resulting predictions of carcinogenic potency.

The mathematical model used to extrapolate from high dose animal experiments to the lower doses likely to be encountered in the environment provides another source of uncertainty. The model is not based on a biological theory of cancer, but rather on a straightforward mathematical extrapolation incorporating the assumption that any dose of a carcinogen, no matter how small, is accompanied by some increase in risk. Differences in the choice of mathematical model for the high dose to low dose extrapolation can make a difference of orders of magnitude in the resulting slope factor. For example, U.S. EPA launched a major review of the carcinogenic potency of dioxin earlier this year because of recent evidence that the potency of dioxin in animals may dramatically overstate that in humans and because new mechanistic information indicates that the toxic effects of dioxin – including carcinogenicity – may exhibit a threshold.

For non-carcinogens, the practice of summing Hazard Indices calculated for many different chemicals for a whole site embodies an assumption that these chemicals might all produce the same non-carcinogenic response. The State of California sums Hazard Indices in a more rational manner – potential liver toxins are grouped together, as are neurotoxins, renal toxins, etc. This practice at least acknowledges that the "threshold" being evaluated (i.e., "Does the total daily dose exceed a safe threshold dose?") at least has a biological basis, however weak.

Finally, for both carcinogens and non-carcinogens, the quality of the data upon which the toxicity indices are based varies greatly from chemical to chemical. Some chemicals regulated as potential human carcinogens by U.S. EPA have numerous animal studies and some supporting human evidence to indicate that the chemical is likely to be carcinogenic. Others, however, have only one or two flawed animal bioassays to support the conclusion. The slope factors, however, are calculated in the same way regardless of the quality of the underlying data. Thus, in risk assessments, it is important that the underlying toxicity data be evaluated in order to present at least a qualitative evaluation of the toxicity data and to illustrate the impact of the uncertainty of those values.

Analytical Data Limitations. Uncertainty associated with chemical analysis can influence the results of a risk assessment. Laboratory contamination, matrix interferences, failure to follow analytical procedure guidelines, and a host of other problems can result in non-representative analytical results. A major source of uncertainty is the problem of concentrations reported as "non-detects." Although analytical techniques are continuously improving, there is always some finite limit below which the presence of a chemical cannot be detected accurately. Consequently, data from environmental sampling efforts are often replete with "non-detects." Since it is not conservative to assume that a non-detect implies zero contaminant concentration, common practice in risk assessments is to assume that a concentration equal to one-half of the limit of detection is present and use this value in estimating representative concentrations. Table 3 demonstrates the effect of assuming different values for "non-detects" when calculating the arithmetic mean from actual site data. Because the true concentrations of those samples reported as "non-detects" is not known, demonstration of the impact of this uncertainty on the estimation of the true representative concentration is not possible.

TABLE 3. TREATMENT OF NON-DETECTS IN ESTIMATING REPRESENTATIVE CONCENTRATIONS

Assumption for Non-Detects	Arithmetic Mean
Non-detects assumed equal to limit of detection	2284 μg/kg
Non-detects assumed equal to one-half the limit of detection	1711 μg/kg
Non-detects assumed equal to zero	1138 μg/kg

Method of Estimating Representative Concentrations. The method of calculating representative contaminant concentrations can dramatically impact the exposure and risk calculations in a risk assessment. Environmental sample data for a given site generally consist of a few reported high concentrations and many more low and non-detected concentrations. Due to this clustering of values close to the limit of detection, environmental data are often log-normally distributed. The appropriate measure of the representative concentration of such a data set is the geometric mean. However, if one assumes that receptors at a hazardous waste site will move randomly about the site and that samples were taken systematically or at random, then over time, the arithmetic mean concentration may describe more accurately the representative concentration to which the receptors might be exposed. U.S. EPA has consequently recommended use of the arithmetic mean concentrations in exposure assessment and has added a degree of conservatism by recommending use of the 95th percentile upper confidence limit on the arithmetic mean. In the past, some risk assessments went to the extreme of using the maximum detected concentration as the representative concentration for all contaminants. Since repeated exposure to the maximum concentration represents a physically impossible situation, this assumption has been discredited because it clearly overstates any possible risks at a given site. Although the upper 95th percentile confidence limit on the arithmetic mean is better in theory, due to the wide variation in concentration values, it is often equal to, nearly equal to, or greater than the maximum detected concentration. Table 4 demonstrates the impact of using different representative concentrations from the same data set on the total risks estimated at a typical hazardous waste site.

TABLE 4. IMPACT OF METHOD OF CALCULATING REPRESENTATIVE CONCENTRATION ON RESULTS OF RISK ASSESSMENT

Representative Concentration	Excess Risk of Cancer (per 1,000,000 population)
Geometric Mean	8
Arithmetic Mean	100
Maximum	9,000

Number and Choice of Exposure Pathways. When performing or reviewing a risk assessment, one must take care to include all potentially relevant exposure pathways. For example, is inhalation a significant route of exposure, or is it completely dominated by incidental ingestion of soil and dust? Failure to include pathways could significantly alter the estimated intakes and risks in a risk assessment. For example, if only incidental ingestion of contaminated soil is considered, a "safe" level established in a permit may actually be inadequately protective if other pathways, such as consumption of drinking water, inhalation of dust and dermal contact with soils contribute significantly to potential exposures.

Values Assumed for Exposure Variables. There is uncertainty associated with the choice of every exposure variable. Current guidance tends to recommend values such that exposures will not be underestimated. Even though the currently favored approach is to estimate a "reasonable maximum exposure," the fact that this scenario makes use of several upper bound values for exposure variables indicates that the resulting estimate is still a very conservative estimate and is likely to overestimate actual exposures.

Of the controversies surrounding the choice of appropriate values for exposure variables, the one regarding the amount of soil and dust inadvertently ingested by children and adults remains the longest standing and most vigorous, perhaps due to the impact of this route on exposure estimates. U.S. EPA continues to recommend soil and dust ingestion rates that overstate ingestion rates reported in recently published studies.

In Directive 9850.4 issued by the Office of Solid Waste and Emergency Response (OSWER), U.S. EPA recommends upper bound values for soil ingestion of 200 mg/day for children up to age 6 and 100 mg/day for all persons over age 6 (U.S. EPA 1989c). Calabrese et al. (1989) performed a rigorous tracer study and estimated median soil and dust ingestion rates of 40 mg/day for children between ages 1 and 4. Gough (1991) concluded that Calabrese's data indicate an upper 95th percentile soil ingestion rate of 70 mg/day. Beck et al. (1989) examined a draft of the Calabrese study and earlier "diaper" studies and determined that both the mean and upper bound of the median value for soil ingestion by children is 50 mg/day. This revised value was estimated by eliminating one child who exhibited an extremely high degree of soil ingestion (5 - 8 grams per day) from the Calabrese study and recalculating mean values. In addition, LaGoy (1987) reviewed several studies and concluded that, for an average case, children aged 1 to 6 ingest approximately 100 mg/day of soil and children aged 6 to 11 ingest 50 mg/day. Although the U.S. EPA-recommended value for soil ingestion by children is not dramatically higher than the values obtained from the scientific literature, it is nonetheless higher, and, therefore, more conservative. Since incidental soil ingestion by children often dominates exposure calculations, overestimating the rate of soil ingestion by a factor of five may result in an equivalent overestimate of total risks. Conversely, overestimating soil ingestion may result in overly stringent safe levels established in permitting or remediation. Table 5 demonstrates the impact of using different ingestion rates on estimating safe levels of benzo[a]pyrene in soils in a residential setting when both ingestion of and dermal contact with soil contribute to exposure.

TABLE 5. IMPACT OF SOIL INGESTION RATE ON ESTIMATING ACCEPTABLE CONTAMINANT LEVELS

	U.S. EPA Default Values (a)	**Values from Scientific Literature**
Adult Soil Ingestion Rate	100 mg/day	25 mg/day (b)
Child Soil Ingestion Rate	200 mg/day	40 mg/day (c)
Safe Level of Benzo[a]pyrene in Soil	**25 ppb**	**40 ppb**

(a) U.S. EPA 1991a
(b) LaGoy 1987
(c) Calabrese et al. 1989

Differences in Receptor Populations. Uncertainty about the future use of a site can also contribute to uncertainty in the risk assessment. For example, at one hazardous waste site, it was postulated that the future use of the site could be residential, industrial, or agricultural. Since the potential for exposure among these receptor groups differs widely, the estimated risks would subsequently differ and the corresponding "safe" contaminant levels would also be different. Due to the substantial costs of cleanup and the massive costs that can be associated with incrementally lower cleanup levels, it is difficult to justify allocation of additional resources to clean up a site to a level that is more protective than is required. Table 6 demonstrates the different action levels that were estimated at a site contaminated with arsenic. Note that the choice of receptor population may result in an order of magnitude difference in estimated action levels, which would significantly alter the scope and cost of any remedial action proposed for the site.

TABLE 6. ESTIMATING ACTION LEVELS FOR DIFFERENT RECEPTOR POPULATIONS

Variable	Agricultural Employee	Industrial Employee	Adult Resident
Soil Ingestion Rate	100 mg/day	25 mg/day	25 mg/day
GI Absorption Fraction	0.80 (a) 1.00 (b)	0.80 (a)	0.80 (a)
Exposure Frequency	90 day/yr (a) 10 day/yr (b)	165 d/yr (a)	245 d/yr (a)
Exposure Duration	40 years	40 years	30 years
Inhalation Rate	1.3 m^3/hr	NA	NA
Inhalation Duration	12 hr/day	NA	NA
Body weight	70 kg	70 kg	70 kg
Life Expectancy	70 years	70 years	70 years
Action Level in Soil	**215 ppm**	**2150 ppm**	**550 ppm**

(a) Ingestion of contaminated soil.
(b) Inhalation of contaminated dust particles.

EVALUATING RISK ASSESSMENTS

Rather than performing an exposure and risk assessment, most people will find themselves in the position of interpreting and evaluating results from risk assessments. Therefore, the task of understanding risk assessments is just as important as is performing a risk assessment. Evaluation should enable the reader to better understand the context and meaning of the results presented in the risk assessment.

Despite the "cookbook" appearance that the current flood of generic guidance from U.S. EPA might give to the performance of risk assessments, the risk assessment process involves a considerable degree of professional judgment, especially when the guidance is tailored to individual site-specific situations. Therefore, evaluating the methodology used in a risk assessment often falls into two separate steps: (1) determining if Agency guidance was followed accurately and appropriately, and (2) determining if professional judgment was used reasonably and appropriately to justify deviations from Agency guidance. All uses of professional judgment must be justified with published scientific literature or site-specific information and data. Careful consideration of the specific site in question is therefore essential to evaluating any risk assessment.

Due to frequent revision, risk assessment guidance materials issued by an agency represent a "moving target." Thus, risk assessments initiated at one time may not be in compliance when finished because subsequent guidance has been issued. Therefore, it is important to keep timing in mind when evaluating a risk assessment. Although completed risk assessments are not required to conform to subsequent guidance, it is possible to estimate the impact of new guidance on results from an old risk assessment. For example, if U.S. EPA were to publish new guidance on soil ingestion rates that recommended a change from the current assumption of 100 mg/day to 25 mg/day for adults, then it is a simple matter to reduce all exposures and risk via this exposure pathway by a factor of four. The relative contribution of this pathway to other pathways will ultimately determine if the change in soil ingestion rates impacts the final risk estimates significantly.

Careful review can identify assumptions that are inappropriate or unjustifiable. There may be so many changes in guidance, inappropriate assumptions, and arithmetic errors in a risk assessment that only a complete recalculation of all exposures and risks can accurately predict the ultimate revised results. In addition, in large risk assessments it is not unusual to find arithmetic errors. The risk assessment should present sufficient detail such that all calculated values can be reproduced. Resource and time availability will determine the thoroughness of the evaluation effort. Figure 1 is a sample list of questions that might be asked as part of an evaluation of a risk assessment. Although the elements used in risk assessments appear to be fairly rigid, it is important to evaluate each situation or circumstance to determine if important site-specific variables are adequately addressed. The following examples help illustrate such site specific factors.

RISK ASSESSMENT EVALUATION CHECKLIST

1. Are all environmental data reported – Are raw data included in an appendix or otherwise readily available?
2. What criteria were used in selecting chemicals of concern?
3. Are there any omissions or inappropriate inclusions in the list of chemicals of concern?
4. Can the reported representative concentrations be duplicated?
5. Are the toxicity constants (RfDs and SFs) consistent with the most recent U.S. EPA values?
6. What are the current and future uses of the site?
7. What receptors are associated with these site use scenarios?
8. How does the site history compare with current and assumed future uses?
9. Do any sources (e.g., meteorological, institutional, etc.) add information to the identification of current and future use scenarios?
10. What exposure pathways are postulated for the groups of receptors?
11. Do the combinations of pathways make sense? Are they reasonable?
12. Are the exposure assumptions consistent with guidance? If not, are they justified by reports in the published scientific literature or site-specific data?
13. Are there any mathematical errors in the exposure calculations?
14. Are there any mathematical errors in the risk characterization calculations?
15. Does the risk assessment contain a detailed discussion of uncertainties and the potential impact of these uncertainties on the results?

FIGURE 1. RISK ASSESSMENT EVALUATION CHECKLIST

Establishing Screening Levels for a Boiler and Furnace Emissions. U.S. EPA promulgated a rule that sets screening levels for the emission of certain metals and hydrogen chloride from boilers and industrial furnaces which burn hazardous waste (U.S. EPA 1991c). The screening levels are used to screen permit applicants to determine whether detailed dispersion modeling of emissions is warranted. Since the purpose of the screening limits is to avoid doing detailed, site-specific modeling at every site requiring a permit, the risk assessment upon which the screening levels are based should be evaluated carefully to determine if it is unrealistically conservative. If the resulting screening levels are unrealistically low, then they are of no practical value because most facilities would be required to perform modeling anyway.

The risk assessment performed in this rule is essentially a risk assessment in reverse. In other words, acceptable air levels of contaminants were determined from available toxicological information, and a set of exposure assumptions used in conjunction with dispersion modeling were used to identify acceptable emission rates from boilers and furnaces. The acceptable air levels were defined by setting a criterion that the maximum exposed individual (MEI) would not be exposed via inhalation to a total lifetime cancer risk of 10^{-5} or to greater than 25 percent of the reference dose for non-carcinogens. The MEI is assumed to reside at the point of maximum annual average contaminant concentrations for a period of 70 years, to inhale twenty cubic meters of air daily and to weigh 70 kilograms. The rule is not consistent with current U.S. EPA guidance. If the exposure duration alone were changed to 30 years, as is recommended in Agency guidance, then the screening levels in this rule would increase by a factor of 2.3. Conservatism is also associated with the dispersion modeling, but the impact of this conservatism on the screening levels is not as easy to estimate. Nevertheless, the screening rules established in this rule are unnecessarily stringent and will result in unnecessary and costly site-specific modeling.

Identifying Action Levels for Remediation. A Feasibility Study performed for a Superfund site estimated a remediation goal for arsenic in soil of 21 ppm. This figure consisted of a "background" concentration of 20 ppm plus a risk-based concentration of 0.23 ppm at a risk level of 10^{-6}. Evaluation of the risk assessment found that inappropriate and overly conservative assumptions had been used in estimating exposures, resulting in artificially stringent clean-up levels. Risks associated with the background concentration of arsenic were estimated to be slightly greater than 10^{-4}, indicating that a risk goal of 10^{-6} for the site was both infeasible and overly stringent, which further implied that a risk goal of 10^{-5} was more appropriate for this site. Furthermore, U.S. EPA policy does not require remediation to background levels if a higher level is protective.

Consequently, using exposure assumptions and risk assessment methods consistent with those recommended in U.S. EPA guidance materials and a risk goal of 10^{-5}, a remediation goal of 100 ppm for adult residents was estimated. Although higher than the previously estimated level, this clean-up level is sufficiently protective of human health and the environment and was estimated in full compliance with U.S. EPA policy and guidance. In addition, establishing the remediation goal at 100 ppm decreased the volume of soil requiring remediation, thereby reducing the size, cost and time required to achieve the clean-up, and also, resulted in less disruption and risk to the surrounding area associated with the clean-up itself.

SUMMARY

Risk assessment is a helpful and effective tool for making risk management decisions. The current emphasis on developing risk assessment methodology and making its practice consistent under various governmental agencies and programs threatens to reduce it to a mere "cookbook" approach to evaluating environmental contamination. While consistency in methodology among risk assessments is desirable, we do not lose sight of the need for professional judgement backed by sound science in risk assessments. As we have shown in this paper, numerous uncertainties in the risk assessment process preclude blind application of one set of assumptions and methods to all sites of interest. Due to the variety of conditions and circumstances across sites, site-specific information and data are of major importance in a properly conducted risk assessment. Professional judgment will always have a central role in performing and conducting risk assessments. Thus, the risk assessment process is not a single set of instructions; rather, it is a methodology that must remain flexible enough to respond to and incorporate circumstances relevant to individual sites and other applications. Risk assessment is of great benefit in the risk management process, but it can never take the place of proper decision making.

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Identification of Potential Environmental and Health Concerns of Soil Remediation Technologies

(L'identification des problèmes potentiels
concernant l'environnement et la santé
provenant des technologies de la
restauration des sols contaminés)

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Health and Environmental Risk Assessment and its Applications in Siting and Operation of Municipal Solid Waste Incinerators

(L'évaluation des risques pour
l'environnement et la santé, et ses
applications dans le choix de
l'emplacement de l'exploitation des
incinérateurs municipaux de déchets solides)

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INCINERATION- A CLEAN STORY

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ABSTRACT

Municipal, medical and hazardous waste incinerators face increasing siting resistance in most geographic areas of the US and Canada. This resistance begins with environmental groups labeling incineration as dangerous, uneconomical, unreliable and a "high risk" disposal option.

Using a rational risk/benefit analysis approach, incineration looks like the best solution in most, if not all of these areas. The analysis includes, threat to public health, reliability and economics. We tend to be pushed towards emotional decisions where the environment is concerned. Decisions reached without careful risk/benefit analysis may be environmentally and economically unwise.

PREMISE

Someone once said that "beauty is in the eye of the beholder." Today it is also apparent that risk is in the mind of the perceiver. This is an unfortunate simile, but nevertheless true. Let me give you some examples. I have listed several common risks and their mortality rates compared with cancer risk from proximity to a municipal incinerator. There is no relationship between actual and perceived risk. People keep smoking despite the evidence that lung cancer is the result, yet they blame other causes, out of their control, as the primary reason for their problems. Psychologists say that this difference is due to the perceived control which the average person believes they have over each of these risk categories.

The risk from an environmental cause, an incinerator, is measured in terms of one additional cancer death per year per one million people. Other risks, voluntary and involuntary, are shown below on the same basis.

ACTUAL RISK TABLE

Risk	Deaths/Million
Alcohol-1 bottle wine/day	75
Smoking-1 pack/day	5,000
Earthquake	1.7
Tornados	2.2
Floods	2.2
Influenza	200
Motor Vehicle Accidents	250
Home Accidents	100
Public Accidents (Drowning, Etc.)	100
Work Related Accidents	65

It is interesting to note that the most significant perceived risk, based upon a survey of college students and the League of Women Voters is nuclear power plants. Not a single death is attributable to this category in the USA to date!

Risk is also a function of magnitude. The United States and Russia agreed to cease above ground testing of nuclear devices because the risk of atmospheric contamination appeared to be greater than the risk of falling behind in the arms race. Underground testing was deemed to be an acceptable risk

Risk may also be affected geographically. In California, building codes require earthquake standards, in New York they do not, because the risk of earthquakes is much greater in California. A risk/benefit analysis of construction costs in New York and California effected this decision.

A reasonable businessman takes a certain number of risks every day. He blends his risk with caution on the basis of the benefits that he will accrue if his judgement is good. Those who take large risks and lose more than 50% of the time do not stay in business, but the real secret to success is to take small risks and win all of the time. The environmental lottery is not without losers but the regulators (federal, state and local) are extremely sensitive to adverse publicity, so they have designed regulations to be as environmentally risk-free as possible while achieving a solid technical base.

IS INCINERATION A RISKY DISPOSAL METHOD?

Incineration is much maligned by environmentalist groups as a disposal method, and I'm not sure why. I do not propose to get into a deep discussion on "recycling". To condemn it would be like being against motherhood. Rationally, however, it must meet an economic benefit criteria that fits our capitalistic society norms, or it must be subsidized, or it must fail! No other option is possible.

Recycling, the war cry of the environmentalist, is a practical consideration for certain materials, and lest I be skewered as an insensitive capitalist clod, I can point to my book "Industrial Waste Disposal", published in 1968, where the advantages of recycling were described. When all has been recycled that can be recycled, there's a lot of waste left! Because recycling is aimed at certain types of paper waste, plastics, glass and metal containers, the residual product is mostly burnable and if it isn't burned it must be landfilled. This does not exclude it's use as a feed for a Refuse Derived Fuel (RDF) operation, but that presumes incineration nevertheless.

Assuming that the recyclable waste has been removed, the only disposal options open at the present are incineration or landfill. If the material is incinerated, as received, it will result in an ash volume less than 90% of the feed which would have been landfilled.

Benefit: Longer landfill life, lower landfill cost.

The material incinerated will have an average heating value of 6500 Btu/lb (3611 Kcal/kg) or more. This means that every ton of waste burned is equivalent to saving slightly less than 1/2 ton of bituminous coal; 90 gallons of fuel oil; or 13,800 cubic feet of natural gas.

Benefit: Free fuel for heating or electrical energy.

Benefit: Conservation of fuel resources.

Associated with these benefits are certain risks. Most, if not all of these, seem to be found in the area of increased air pollution.

AIR POLLUTION RISKS FROM INCINERATION

There is no doubt that public perception of air pollution control methods, especially with regard to incinerators is poor. This perception has been caused by past poor standards and enforcement. Those days are over! Ambient air quality regulations and regulations governing incinerator emissions, in general, have made the risk of living near an incinerator technically if not emotionally minimal.

Another unexplained factor in this assessment is the relatively small part which incineration of all types plays in the waste disposal picture. Risk is certainly a factor of size, so the relative capacity of the present incineration market compared to other pollution sources needs to be seen in terms of its overall effect on the environment. This is an important variable which has been carefully avoided by the opponents of incineration.

The USEPA has designated incineration as BADT (Best Available Demonstrated Treatment) for hazardous waste. Most states now accept lime injection followed by a baghouse as BACT (Best Available Control Technology) for incinerator emissions. See Figure 1. The relative risk/benefit conclusions reached here are based upon the use of this type of air pollution control system.

Major air pollutants from incinerators are:

Particulate matter
Metals
HCl
Cl_2
SO_2
NO_x
CO
Hydrocarbons
Products of incomplete combustion (PICs) including chlorinated dioxins and furans.

Three generic types of incinerator applications represent most of the incineration capacity now in operation. They are: Hazardous Waste Incinerators, Municipal Waste Incinerators and Medical Waste Incinerators. The installed capacity of each and percentage of total incineration capacity in the United States follows.

Type	Capacity, TPD	% of Total
Municipal waste	194,475	92.2
Hazardous waste	15,122	7.2
Regulated medical waste	1,276	0.6
Total	210,873	100.0

HAZARDOUS WASTE INCINERATORS

At the present, there are 17 commercial hazardous waste incinerators in the USA and perhaps less than 350 industrial incinerators burning RCRA classified hazardous waste. In addition there are possibly 500 or so industrial furnaces, boilers and cement kilns which utilize RCRA waste as a fuel. Since the BIF rule became law in February of this year, all burning facilities, now or in the near future (including RCRA incinerators under the omnibus authority) will have to meet the same emission restrictions. The federal regulations prevail, however many state regulations are more stringent. (Canadian emission regulations are generally tighter than US regulations.)

The US Federal regulations are:

Particulate: 0.08 grains/dscf = 180 mg/dscm * Corrected to 7% O_2

CO: 100 ppmv 60 min rolling average corrected to 7% oxygen

HC: 99.99% DRE based on Trial Burn

Metal, HCl & Cl_2: Risk based criteria $1x10^{-5}$

SO_2 & NO_x: Currently based on area attainment.

Dioxins: There are no current federal regulations governing emissions, however, measured emissions appear to be on the order of 0.1 to 0.5 ng/Nm^3.

* (Many state air regulations require much lower particulate emission levels)

The amount of hazardous waste incinerated in the United States is small in comparison to MSW incineration. The largest commercial operators can burn only 150 million Btu/hr of waste which translates into small emission numbers based upon regulatory constraints. These facilities eliminate organic compounds from entering the environment through ground water contamination, reduce the amount of material to be landfilled by 80 % and provide risk acceptable air emission levels of organics, metals and acid gases.

Benefits: Destruction of organic waste components. Reduction of waste volume up to 80%.

Risk: Monitored and risk controlled emissions to atmosphere.

Reliability: Excellent track record. Most units are simple and rugged and have automatic fail safe features.

MUNICIPAL INCINERATORS

Municipal incineration today is a mixed bag. It consists of modern systems which will meet current and future air quality regulations and existing systems which need upgrading to meet these regulations. Unlike hazardous waste incineration, however, it is widely used for energy recovery.

There are 128 waste to energy facilities and 40 incinerators in the US which burn 28.6 million tons/yr. (about 16% of the 180 million tons of MSW generated each year.) This is equivalent to 2000 MW of electric generating capacity which could supply the needs of 1.3 million homes. It represents a fuel equivalency of nearly 27 million barrels of crude oil. This is about 13 % of the oil now used in the US to generate electricity and represents a real but un-quantified reduction in acid rain potential.

The trade off for this "free fuel" is the potential for greater air pollution in certain categories. Since environmentalists don't want to discuss clean nuclear energy let's look at MSW waste to energy vs. fossil fueled plants excluding natural gas. To do this, it is necessary to consider comparable facilities of each type, i.e. new plants which must meet current air regulations.

The particulate emissions for MSW waste to energy plants will be comparable to coal fired utility systems. New MSW incinerators over 250 TPD are required to meet 0.015 grains/dscf corrected to 7 % O_2. The NO_x and CO emissions will be approximately the same. HCl and Cl_2 emissions will be slightly higher and SO_2 emissions significantly lower but both will be within current regulatory bounds. Metals emissions will probably be greater based upon current MSW metal content but emissions will meet risk based levels set by the USEPA. Dioxin emissions will probably be higher than for hazardous waste incinerators but tests on modern systems using the air pollution control system, shown in Figure 1, has achieved a range of 1 to 30 ng/Nm^3 for total TCDD and TCDF emissions.

Benefits: Reduction in volume of waste by 90% or more. Longer landfill life, less space required. Significant savings in fossil fuels. Inexpensive energy source.

Risk: Increased air emissions of some contaminants.

Reliability: Depends upon operator training, inspection and maintenance. New systems more reliable and more completely computerized.

REGULATED MEDICAL WASTE INCINERATORS

The generation rate of this waste is minuscule compared to the other sources. The incinerators are small and heat recovery is applied to less than half of the incinerators. Because of the incinerator size, regulations usually permit higher emissions of every pollutant than found in the other two incinerator categories but because the total volume is small the overall contribution to air pollution is small in comparison. This is an excellent argument for the establishment of regional medical waste incineration facilities. Some states now require that the "dry scrubber" - baghouse air pollution control system be used on this type of incinerator. In many cases it is too expensive to consider compared to sterilization methods for the waste.

Benefits:	90% volume reduction. Aesthetically acceptable disposal. Best method for pathogen destruction.
Risk:	Increased air emissions.
Reliability:	Varies based upon operator training.

CONCLUSIONS

Even the environmentalists who oppose incineration concede that a properly operated modern incinerator poses very little risk from most of its controlled pollutants. They base their opposition primarily on metal emissions and emissions of chlorinated dioxins and furans and the risk that these pose to public health.

The metal emission data which has been developed on existing incinerators shows that they are generally within the risk based criteria proposed by the USEPA and that criteria appears to be conservative on the basis of toxicological information.

The TCDD, TCDF controversy is considerably more ephemeral. The measured emission levels, for these compounds, from modern incinerator systems are on the order of several nanograms per cubic meter. The problem is that no one has really quantified the health risk of such small emissions which represent picogram quantities at ground level.

The volume reduction of waste plus the conversion of MSW to useable energy seems to far outweigh the potential health risks associated with modern incinerators.

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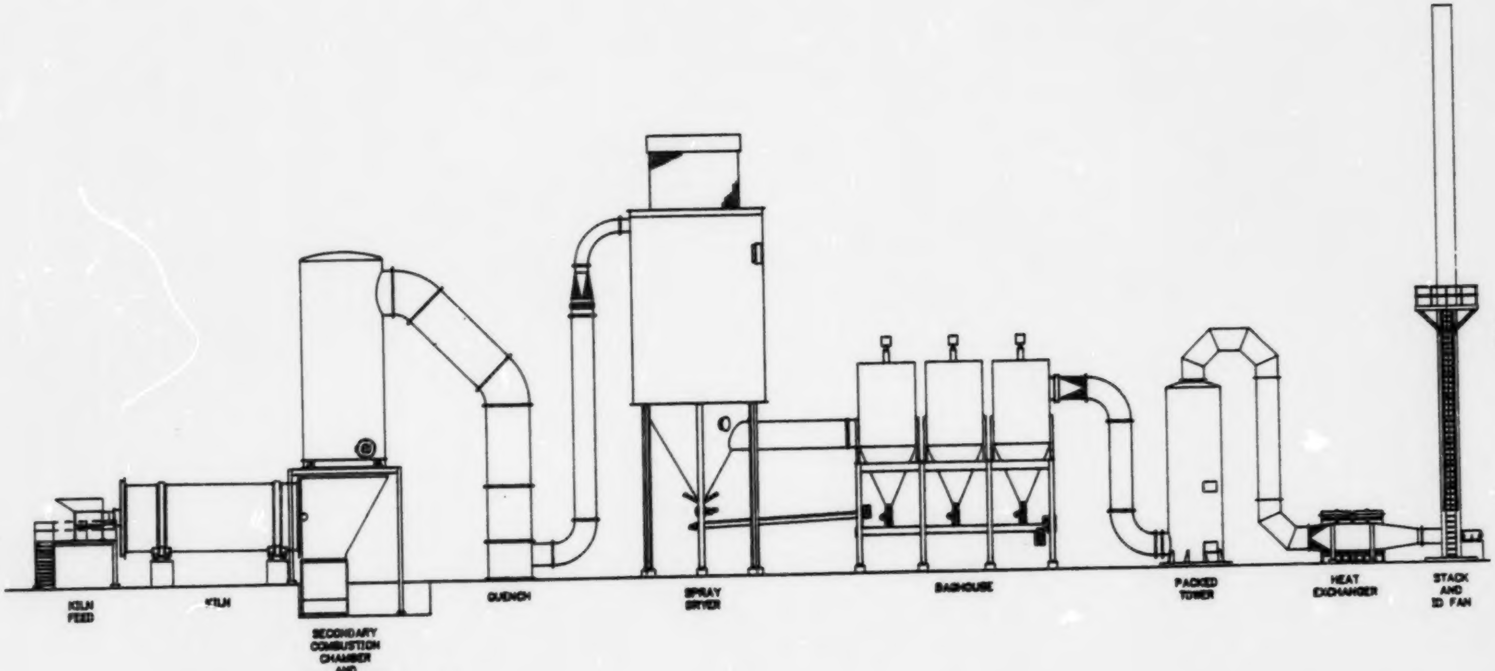
KILN FEED
KILN
SECONDARY COMBUSTION CHAMBER AND ASH DISCHARGE
QUENCH
SPRAY DRYER
BAGHOUSE
PACKED TOWER
HEAT EXCHANGER
STACK AND ID FAN

FIGURE 1

FOUR NINES, INC.
PLYMOUTH MEETING, PA
DECATUR, GA HOUSTON, TX

WASTE MINIMIZATION: BEFORE OR AFTER THE FACT?

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Background

Waste minimization can be effectively achieved both before the waste is produced (waste reduction) and after the fact (waste reuse and recycle). For a number of years, we have been discussing the Waste Management Hierarchy which puts Waste Reduction as the ultimate solution, viz don't make the waste in the first place. While agreeing that, philosophically, waste reduction is the best solution. From a practical point of view, a combination of reduction, reuse and recycle approaches are likely to result in the greatest diversion from disposal.

For the purposes of this paper's discussion, we would like to differentiate between "material or product reuse" and "waste reuse". From our point of view, material or product reuse would be an option for "waste reduction". For example, the substitution of a reusable plastic tote for single use cardboard boxes **reduces** the volumes of **waste** produced. An example of "waste reuse" would be the direct utilization of a slightly contaminated solvent waste from the electronics industry by paint manufacturers, compared to "waste recycle" which would involve the distillation of a more contaminated solvent to recover solvent, but also leave a residue.

Understanding the Problem and the Opportunity

The first step in waste minimization for any company, institution or community is to understand the problem and the opportunities this presents for waste minimization. This is achieved through a detailed waste audit. We define a detailed waste audit as:

> **"An evaluation of the types and quantities of waste material generated per activity area and an understanding of how and why that waste is produced."**

What we are talking about goes a lot further than a simple checking of quantities of waste shipped for disposal each week. It requires a thorough understanding of how and where the wastes are generated within the industry of institution. As an example of what we mean by a detailed waste audit, we will briefly describe the auditing of Ottawa General Hospital, recently undertaken by ORTECH.

Waste types were defined: first 7 major waste types were defined:

Clean General Waste
Clean Confidential Waste
Non-Anatomical Biomedical Waste
Anatomical Waste
Chemical and Liquid Waste
Radioactive Waste
Pharmaceutical Waste

The Clean General Waste, which constitutes over 90% of the total hospital waste, was subdivided into a number of material subcategories chosen to allow us to consider reduction, reuse or recycle options, e.g. glass was divided into container glass and borosilicate glass because the potential for recycle of these two types is quite different.

The hospital was then split into "Activity Areas" under 4 major headings: Patient Care; Patient Services; Laboratories: and Admin and Support. These major activities were further subdivided into 78 individual areas, e.g. within Patient Care - Obstetrics, General Medicine, Neurology, etc.

Generation rates for the individual areas for the 7 major waste types were measured or estimated. The composition of the Clean General Waste was determined by sorting all of the waste generated by a specific activity area over a 24-hour period.

Interviews were held with staff in each of the activity areas to understand the activities occurring and to determine an "activity factor" for that particular area. For example, in Patient Care areas, activity factors used were numbers of beds occupied; for Labs, numbers of samples analyzed per year.

As a result of this detailed audit, ORTECH developed a matrix chart with "specific generation factors" for individual waste components from individual activity factors expressed in kg/year per activity factor. These factors could be used by any similar hospital to predict waste generation rates. For example, in the Obstetrics area, we determined that 8.2 kg/year of boxboard is produced per occupied bed. Thus, any hospital can use this figure to predict boxboard generation for their Obstetrics department by multiplying by the number of occupied beds they have.

The other information that was gathered in interviews throughout the hospital helped us to understand the practical constraints in considering waste minimization options.

At the end of the audit phase, information is available on the quantities of waste generated and where those wastes arise. This information can be used to determine priorities in terms of which waste streams should be examined to have the biggest impact on volumes of waste going for disposal. Information is also available about the activities generating the waste so that sensible consideration can be given to options to reduce, reuse and recycle.

Opportunities for Waste Reduction

Having developed a thorough understanding of waste being generated and the activities leading to that generation of waste, one is in a position to examine ways of reducing the waste produced.

It is extremely important to recognize that satisfying needs of the particular activity (provided those needs are real and reasonable) has to be the first consideration. For example, reducing food packaging to the point where the food spoils obviously makes no sense: it wastes resources and, in fact, increases waste because both the product and package go for disposal.

In the hospital context, there are many considerations of patient and health care worker safety that have to be a prime consideration when examining waste reduction options. When health and safety needs are satisfied, then the economic viability of waste reduction measures need to be considered. Hospitals work under considerable budget constraints so that changes to reduce waste must be economically reasonable to implement.

With all of these constraints in place, can waste be reduced? Yes, but what these constraints do is to focus and put into priority order opportunities for waste reduction.

For example, an obvious way to reduce the quantities of packaging waste is through buying in bulk. Hospitals buy cleaning products, and injectable drugs in small quantity and single use packages, which lead to quite significant volumes of packaging waste. Concerns about cross contamination from bulk injectables suggest that this may not be the easiest of changes to make. These same constraints do not apply to cleaning products so that this would be the first place to look for package reduction through buying in bulk.

Similarly, in considering package reuse, the reuse of packages containing sterile drug products would probably not be the first place to look for a reusable system for hospitals. Returnable plastic tote boxes as a substitute for corrugated cardboard outer containers for single use sterile packages would not affect patient or health care worker safety, and would also have an even more significant impact on waste generation as corrugated cardboard is a major component of hospital waste.

Another consideration in waste reduction/material reuse is the impact of this on other environmental media, of laundering or cleaning of reusable items.

One very controversial area is the consideration of cloth diapers in hospitals versus single use disposables. Questions are raised about:

- Patient and health care worker safety
- Economics
- Overall environmental impact

Opportunities for Waste Recycle

For wastes where reduction is not considered appropriate at this time, there still exists the possibility of diverting waste from disposal through recycle or reuse. Once again, there is a "before or after the fact" decision to be made. Do you accept the waste as it is currently generated **after** use or do you try to "improve the quality" of the waste **before** it is generated? Improving the quality of the waste can involve either infrastructure changes to segregate recyclable wastes from non-recyclable wastes or actual redesign of the product or package to improve its recyclability.

As an example, we would like to discuss a project ORTECH is undertaking with Astra Pharma in community pharmacies to examine the potential for plastics recycling.

Plastic waste is mixed with all other wastes from pharmacies and is disposed through regular waste disposal, giving it no value as a recyclable material. In an initial pilot, we installed separate bins, both behind the counter for pharmacists to dispose of plastic drug containers, and in front of the counter for customers to deposit empty plastic vials. We got excellent response to the program from both pharmacists and customers.

Samples of the mixed plastic waste were evaluated by a plastic recycler who agreed that he could use the material.

An expanded pilot, involving about 30 pharmacies, is currently under way to test the efficacy of collecting the segregated plastic using the current pharmacy delivery system working in reverse. This pilot will give us excellent data about the problems that might be encountered in collecting recyclables and the true costs associated with this approach to collection.

If this infrastructure proves to be effective, the next obvious step is to examine the potential to change this packaging to increase its value for recycling. If all plastic packaging used in the pharmaceutical industry could be made from a single polymer type, the value of the reclaimed plastic would be greatly enhanced. If the labelling used on this plastic could be made of the same polymer rather than of paper, again the value would be increased. Both these design changes are technically feasible and would contribute significantly to the recyclability of this plastic waste from the point of view of both more diverse markets and the economics.

Other examples from our work on hospital waste are also interesting. Single use injectables have been delivered in packages that are a recycler's nightmare, consisting of borosilicate glass with a rubber septum, and aluminum cap. These are packaged in boxboard and shrink wrapped in polyethylene. A single use package has been developed, known as a Polyamp, which is made from polyethylene. Thus, the glass, rubber, aluminum combination is replaced by polyethylene. Currently, these are still packaged in boxboard with a polyethylene shrink wrap. The obvious next step is to eliminate the boxboard.

A relatively large proportion of hospital waste is potentially compostible. 15-20% is food waste. Other wet paper waste makes up a significant portion as does other currently non-recyclable dry paper. In all, about 40% of the hospital waste was identified as being potentially compostible.

Again, the quality of the compost product could be enhanced if all of the potentially compostible waste were "designed" with this waste recycling option in mind. Products such as disposable diapers, incontinence pads, sterile packaging, etc., are mainly compostible, but have plastic components which will certainly detract from the aesthetics of the compost product. Boxboard, which might also be composted, should not be printed with inks that would introduce heavy metals to the compost product. Research is currently under way to look for replacements for the non-compostible components of diapers, and, certainly, inks can be chosen that have no heavy metals.

After all of the changes are made to "improve the quality" of the waste, a hospital or company still needs to find a recycling or reuse market for those wastes. Since 1978, ORTECH has been operating the Canadian Waste Materials Exchange. This project is funded by Environment Canada, a number of the Provinces, plus industrial participants. The objective of a Waste Exchange is to match generators of waste with potential users of those wastes. Since its inception, CWME has achieved about 700 matches of generators with users, diverting about 250,000 tonnes per year of wastes produced on an ongoing basis, and a further 110,000 tonnes of wastes produced one time only.

The CWME operates by publishing a bulletin six times per year which is distributed to about 3,000 participants in the programme. Listings of available and wanted wastes appear in each issue. We rely on the participants to find wastes of interest to them from this bulletin.

Since 1984, ORTECH has also been operating the Ontario Waste Exchange, co-funded by Ontario Waste Management Corporation and the Ontario Ministry of the Environment. The Ontario Waste Exchange more actively pursues potential exchanges in Ontario, by telephone, plant visits, etc.

Regional Exchanges have also been established in Alberta, Manitoba and British Columbia. Work is currently under way to set up Waste Exchanges in Saskatchewan and Quebec.

The Federal Government's "Green Plan" calls for a strengthening and extension of the national network of Waste Exchanges. We all welcome this support and look forward to funding being in place to expand the activities of all of the Waste Exchanges.

Contacts for further information about all of the Waste Exchanges are as follows:

Alberta	Bill Kay	(403) 450-5408
British Columbia	Tim Reeve	(604) 731-7222
Canadian Waste Exchange	Bob Laughlin	(416) 822-4111 (ext. 265)
	Isobel Duncan	(416) 822-4111 (ext. 266)
Manitoba Waste Exchange	Beth Candlish	(204) 257-3891
Ontario Waste Exchange	Mary Jane Hanley	(416) 822-4111 (ext. 358)
	Dianne Lawson	(416) 822-4111 (ext. 656)
Saskatchewan	Eugene Ogu	(306) 787-9800

Summary

In summary, there are many things that can be done "before the fact" to enhance the efficacy of reduction, reuse and recycle. Reduction is entirely before the fact in eliminating the production of waste. But, for both reuse and recycling options, there are many changes that can occur before the waste is generated to enhance the recyclability of materials and packaging.

IRRADIATION STERILIZERS FOR BIOMEDICAL WASTE TREATMENT AND SLUDGE RECYCLING

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Canada K2K 1X8

INTRODUCTION

Until fairly recently, commonly employed waste treatment technologies were readily accepted. Over the last several years, however, public opposition to new incinerators and landfills, coupled with increasing regulatory requirements for these and other traditional options has led to a search for new technologies able to recycle wastes or render them safe without adversely affecting the environment.

Irradiation sterilizers have been used worldwide for almost thirty years to sterilize a wide range of medical products, pharmaceuticals and consumer goods. The safe, efficient, reliable and large-volume sterilization capability of irradiation sterilization systems appears to offer industry and governments another viable alternative for treating potentially infectious wastes.

During the last four years, a testing and development program initiated by Nordion International Inc. has investigated and defined the role that could be played by irradiation sterilizers in waste management applications. This paper discusses irradiation technology in relation the two waste treatment applications which appear to be most relevant - sterilization of biomedical waste and pasteurization of municipal sewage sludges to enable recycling.

IRRADIATION STERILIZATION TECHNOLOGY

Irradiation sterilization is a well understood and relatively widely-used technology. Approximately 50% of all medical supplies used in North America are sterilized by irradiation systems. There are approximately 40 facilities in North America and over 150 worldwide. These sterilizers do their job efficiently and reliably without heat, steam or chemicals. The sterilizing 'agent' is high-energy, gamma waves emitted from a deliberately produced radio-isotope called cobalt 60.

Whether biomedical waste is to be sterilized, or sewage sludge is to be disinfected prior to recycling, the irradiation process is essentially the same. [Refer to Figures 1 and 2].

Potentially infectious wastes are loaded into metal boxes, carriers or bins that form a 'product conveyor system'. The product conveyor system automatically and continuously moves the waste into a concrete-walled irradiation room, and past a rack that holds a number of cobalt 60 rods. As the waste moves past the rods, gamma rays emitted by the cobalt 60 penetrate all parts of the waste, killing microorganisms. Otherwise, the waste is left virtually unchanged. In no instance is the waste or its containers made radioactive.

Once the waste has received the required treatment (disinfection/sterilization), it is automatically moved out of the irradiation room. The rendered-safe waste is immediately ready for whatever post treatment use or process is desired (recycling, shredding, compaction etc).

IRRADIATOR SAFETY

To those unfamiliar with irradiation sterilization technology, questions most often focus on the production and safety of cobalt 60.

Cobalt 60 is a deliberately produced isotope of naturally-occurring cobalt 59, a solid metal-like material. Cobalt 59 is fashioned into small pellets, sealed in stainless steel rods, and sent to a Canadian Candu nuclear power reactor. At the reactor, the cobalt 59 rods are placed inside the reactor for a period of one to two years, where they are bombarded with neutrons. The resultant cobalt 60 [a radioisotope of cobalt 59] is then removed from the reactor, processed to meet medical and industrial needs, and shipped worldwide to literally thousands of users.

The production, transportation, use and disposal of cobalt 60 is carried out under strict regulations set out by national and international agencies. Many millions of curies of cobalt 60 have been shipped worldwide since the early 1960's, without incident. The process is safe, well-understood, and achieves its objective without harmful air, soil or water emissions.

BIOMEDICAL WASTE STERILIZATION

Introduction

Provided waste segregation is a realistic possibility in the hospitals, clinics and laboratories which generate the majority of medical wastes, and provided the concept of transporting the waste off-site for treatment (in a regional facility) is accepted then it is realistic to consider irradiation sterilization technology in lieu of incineration, autoclaving, chemical disinfection, and other novel/emerging ideas.

Irradiation sterilization only sterilizes. It does not destroy toxics; it does not render flammable liquids safe; it does not render body parts unrecognizable. Consequently the generators of medical waste must be prepared to separate their waste at the source. Only the potentially infectious portion would be eligible for irradiation sterilization. This however is a significant portion of the medical waste stream.

Irradiation sterilization systems are economic in relation to incineration and autoclaving only at daily throughput loads of greater than 5 tons. We do not believe it is possible to design a price/cost competitive system small enough to serve a single hospital. Consequently, potential users must think in terms of a central or regional facility providing a service to several or many hospitals. One modest-sized irradiation facility capitalized at 3-5 million dollars could easily sterilize all of the potential infectious medical waste produced by a city of 2 million people. One medium-sized facility could easily sterilize all of the potential infectious medical waste generated in Ontario, Canada (9 million people).

Irradiation sterilizers are used world-wide to sterilize every imaginable type, shape and form of packaging material. There is absolutely no doubt in the minds of informed specialists that irradiation systems can reliably sterilize medical wastes. If guaranteed, reliable, consistent sterilization is the primary concern, then irradiation is more than competitive with all competitive technologies. If segregation is realistic to consider and centralized treatment of >5 tons per day is envisioned, then irradiation should always be considered.

Process Overview

Following is a description of a typical biomedical waste irradiation facility processing scenario (refer to Figure 1) :

- Bagged or otherwise 'containerized' infectious waste is transported from a number of hospitals to a centralized or regional Waste Treatment Centre, at which an irradiation sterilizer is located.
- At the Centre, the bags are given an initial screening for quality control prior to being loaded onto the Product Conveyor System for irradiation-sterilization.
- The sterilizer will "render safe" potentially infectious biomedical waste reliably, safely and in an environmentally benign manner. If a post-treatment shredding and compaction system is added to the sterilizer, then a regulatory 'render unrecognizable' requirement can also be met. The resultant compacted, shredded, non-infectious waste is now suitable for placement in a local landfill or can be used as fuel in materials furnaces, kilns, etc. In addition, some plastics (e.g. sharp containers and contents) could be removed from the treated wastes for recycling.

Regulatory Environment

Currently, regulations regarding the handling, transport, treatment and disposal of potentially infectious biomedical wastes remain under the jurisdiction of each Province in Canada and each State in the U.S.A. The degree of regulation is increasing dramatically, and specific regulatory requirements vary dramatically throughout North America. There are, however, signs that some form of consensus regarding minimum standards will be achieved through Federal Government intervention. These standards, together with increased regulatory involvement, will continue to receive attention as existing biomedical waste incinerators are closed due to an inability to comply with air and ash emission limits, as new incinerator proposals fall under public opposition, and as regional/centralised treatment facilities become the norm.

Irradiation is an approved method of biomedical infectious waste treatment prior to placement in landfill in three U.S. States [Arkansas, Indiana and Pennsylvania]. The door is open in most states and provinces in that "other methods" of treatment, as yet unspecified, may be approved. In Canada, irradiation is not specifically identified as an approved sterilization method for biomedical waste, but it is an approved and well accepted sterilization method for medical supplies. If steam heat has been approved then there will be no difficulty in obtaining approval for irradiation sterilization.

SLUDGE RECYCLING APPLICATIONS

Introduction

There is today a world-wide trend toward more environmentally positive alternatives for handling society's wastes - widespread recycling and reduction initiatives are examples. This trend has already impacted on ways that municipal sewage sludge is managed. In many countries, for example, there is an escalating move away from ocean dumping, landfilling and incineration, due to concerns about pollution and misuse of resources. The trend is leading us towards beneficial land-based uses of sludge as a means of recycling, and towards advanced technologies as a means of disposal.

It is possible to reduce disposal costs and use sludge in a more environmentally beneficial way by recycling the sludge to take advantage of its nutrient value. Nitrogen, phosphorus and trace metals are found in sludge and are valuable to plant growth. In order to safely sell and use sludge products though, harmful organisms which occur naturally in sludges must be eliminated or reduced to very low levels. These organisms, called pathogens, include viruses, bacteria and parasites which could cause disease in humans or animals.

For many sludge recycling processes, one of the persistent problems is ensuring reliable pathogen kill. The majority of pathogens can be killed by heat provided the correct temperature is reached and maintained for a prolonged period of time. The diverse and changing nature of sludge can make this difficult, especially in cold and/or wet climates. At the same time, regulatory trends towards demanding that no pathogenic organisms be detected in sludge used by the public or spread on land accessible to the public means that proper operation of recycling processes is essential.

As has already been described, irradiation sterilizers offer a demonstrably reliable, consistent method of pathogen elimination, and when pathogens are no longer a concern, the material that remains is an organic material rich in plant nutrients. All that then needs to be done is to air-dry the sludge so that it can be more easily bagged or transported in bulk. The resultant fertilizer or soil agent has value - that is, it can be sold to increase revenue or given away to reduce disposal costs.

Irradiation sterilization costs and cost saving expectations are situational, but it is correct to say, as is also the case with biomedical waste treatment, that economies of scale are evident and that a critical volume of sludge is required. Our economic studies to-date indicate that municipalities with more than 250,000 people should consider irradiation as a viable option in the first instance. Detailed examination of technology and recycling alternatives in relation to the specific situation will be required to confirm the best choice.

Process Overview

Following is a description of a typical sewage sludge irradiation facility processing scenario (refer to Figure 2) :

- Municipal sewage sludge treatment processes typically include aerobic or anaerobic digestion for sludge stabilization. Following digestion, sludges are approximately 97% water and 3% solids, and can be applied to agricultural land in this form. If, however, the sludge is destined for irradiation disinfection and recycling, economic studies have shown a definite advantage to following the digestion process with a dewatering stage to reduce water content to 75% or less.
- Dewatered sludge is metered into aluminum boxes that form part of the Product Conveyor System. As described previously, these boxes move automatically into the irradiation room where the sludge is disinfected. Boxes are then conveyed to a dumping area where the disinfected sludge is moved to an (outdoor) mixing area.
- Sludge is mixed with woodchips, formed into piles and allowed to dry for approximately two weeks, after which the wood chips are screened out and the organic sludge product is ready for bagging/sale/use.

Regulatory Environment

In Canada, the benefits of sludge utilization, rather than disposal, are being realized to a limited extent through land application and composting. Regulations generally encourage sludge use, but cost-effective and reliable pathogen destruction can be a stumbling block to achieving more successful utilization programs. A consistently reliable and cost-effective method of reducing or eliminating pathogens in sludge, coupled with significantly shortened drying times, would remove some of the stumbling blocks to achieving successful sludge recycling programs.

The Canadian Department of Agriculture already has a mandate to withdraw microbially-contaminated sludge products from markets. A committee has been established to study microorganisms in sludge and to recommend regulations regarding permissible levels in sludge-based products used by industry and the public.

In addition, the U.S. Environmental Protection Agency, has recently proposed new regulations for microbial levels in sludge-based products offered for sale to, or use by, the public. These regulations, due to become law in 1992, call for very low levels of pathogenic organisms in sludge products. Users of traditional sludge composting systems are just now beginning to question the ability of their operations to comply with these new requirements.

As concern for the environment escalates, more stringent regulations and monitoring are also expected, in particular with respect to wastes. There is, then, an almost universal movement towards implementing microbial regulations on recycled sludges.

SUMMARY/CONCLUDING REMARKS

Biomedical waste & sewage sludge irradiation sterilizers are environmentally clean, requiring no special pollution control devices. No chemicals are used, no stack gases are generated, and no toxic changes occur in the waste. These systems have been widely used around the world to sterilize medical and consumer products, and are now available for waste treatment. Their simplicity and ease of operation translates to reliability and cost competitiveness with other treatment options.

Irradiation sterilization of potentially infectious biomedical wastes, while not feasible on a per-hospital basis, presents opportunities for significant cost reduction if performed at a regional or centralized facility. The diversion of the infectious component of biomedical wastes to an irradiation sterilizer will result in more available incinerator capacity for the processing of increased volumes of toxic and hazardous wastes.

Irradiation-disinfection of municipal sewage sludge offers the obvious benefit of eliminating potentially harmful organisms to allow waste to be recycled and put to beneficial use. In tandem with this is the reduction of air and water pollutants through reduced reliance on sludge incinerators, landfills and ocean/river dumping practices.

Although irradiation-disinfection of municipal sewage sludges is not applicable to all sewage treatment plants, there are situations [i.e.: land shortages, high landfill costs, a desire to recycle, etc.] where this technology can be shown to be the most economically and environmentally attractive option. Valuable landfill and incinerator capacity can be freed-up, sludge can be recycled into a useful soil product, plant operating costs can be reduced, and another option on the short list of acceptable sludge disposal alternatives can be provided.

This 'new', all-Canadian technology provides another spoke in the waste treatment wheel and deserves serious consideration by all those with responsibility for safe, clean, reliable waste management programs.

INDUSTRIAL IRRADIATOR
BIOMEDICAL WASTE TREATMENT SYSTEM

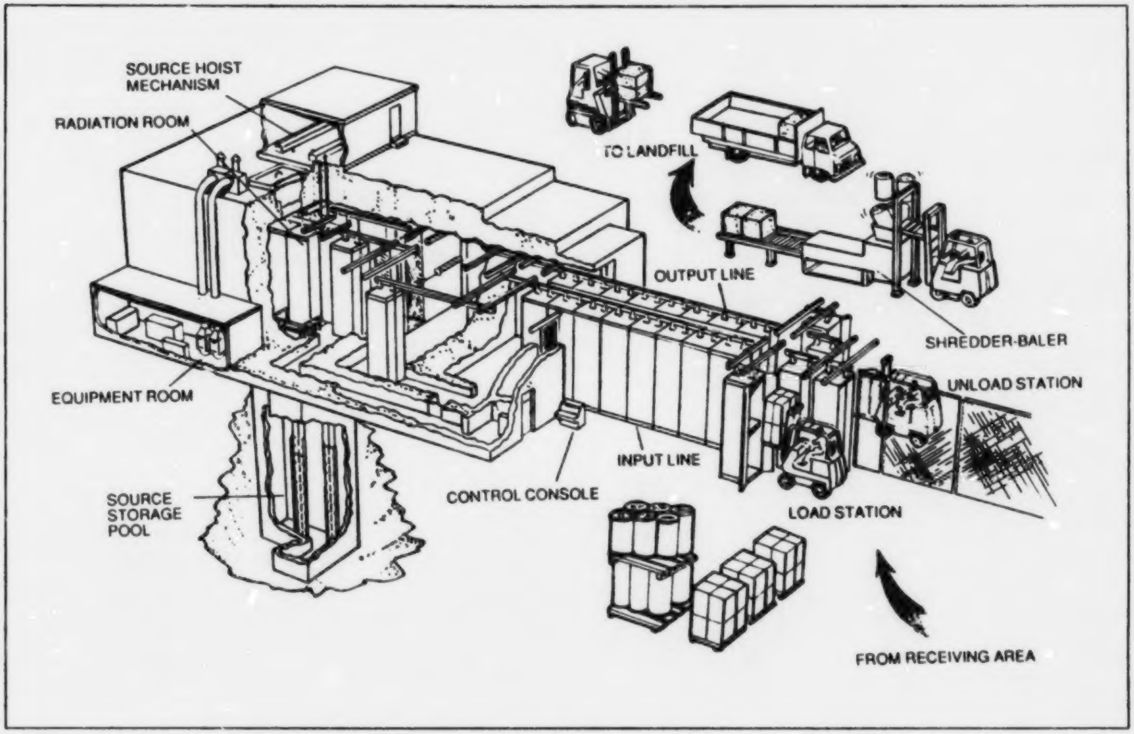
SOURCE HOIST MECHANISM
RADIATION ROOM
TO LANDFILL
OUTPUT LINE
SHREDDER-BALER
UNLOAD STATION
EQUIPMENT ROOM
INPUT LINE
CONTROL CONSOLE
SOURCE STORAGE POOL
LOAD STATION
FROM RECEIVING AREA

FIGURE 1

INDUSTRIAL IRRADIATOR
MUNICIPAL SLUDGE DISINFECTION SYSTEMS

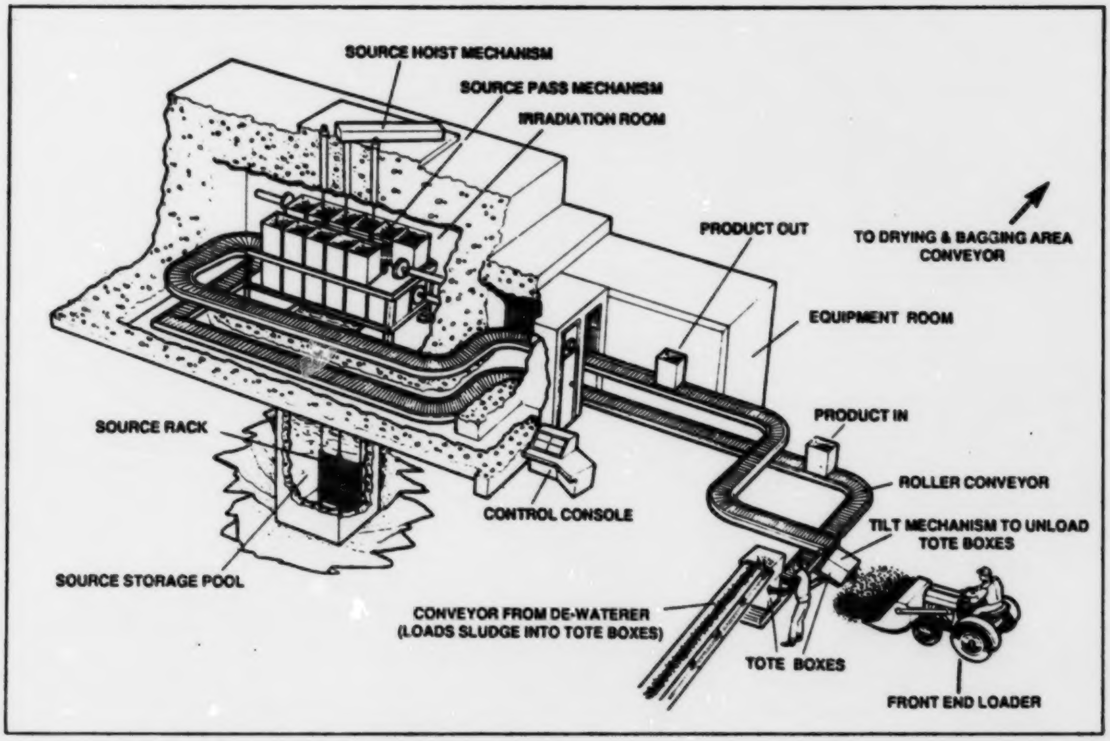
SOURCE HOIST MECHANISM
SOURCE PASS MECHANISM
IRRADIATION ROOM
PRODUCT OUT
TO DRYING & BAGGING AREA CONVEYOR
EQUIPMENT ROOM
PRODUCT IN
SOURCE RACK
ROLLER CONVEYOR
CONTROL CONSOLE
TILT MECHANISM TO UNLOAD TOTE BOXES
SOURCE STORAGE POOL
CONVEYOR FROM DE-WATERER (LOADS SLUDGE INTO TOTE BOXES)
TOTE BOXES
FRONT END LOADER

FIGURE 2

Waste Tire Disposal Issues

(Les problèmes relatifs à l'élimination des pneus usagés)

J. Michael Kennedy Jr.
Recycle America
Oak Brook, Illinois

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

Waking up to 'Tired' Roads: Government Demand for Rubberized Asphalt as a Solution to Scrap Tire Stockpiles

(L'éveil aux routes 'pneumatiques':
la demande d'asphalte caoutchouté par les
pouvoirs publics comme solution à
l'entassement des pneus de rebuts)

Janet Matthews
New York State Legislative Commission on
Solid Waste Management
Albany, New York

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ESTIMATES AND SOURCES OF HAZARDOUS WASTE LOADING IN A MUNICIPAL LANDFILL IN A RESOURCE-BASED COMMUNITY

by

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Edmonton, Alberta, T6G 2G7

ABSTRACT

While much attention and effort have been focussed on recycling of materials to reduce landfill space, small quantities of potentially hazardous products in the municipal waste stream may contribute significantly to the environmental impacts and risks of waste facilities. In order to properly manage these materials, quantities and sources must be identified. A systematic program was used to obtain representative values for means and variation of hazardous products in the waste stream entering the landfill. Seasonal mean weight fractions of hazardous products amount to 6.54% (± 0.45%) in winter, 7.86% (±2.96%) in spring, and 4.05% (±1.12%) in summer. These values are substantially higher than the 0.3 to 1% reported in previous studies. Town residential waste consistently contains 3.0 to 3.7%, while hazardous products in both small vehicle and large rural transfer station loads amount to between 1.3% and 17.4% of the waste stream weights..

Based on an analysis of the sources and on the type of materials, some patterns in the waste generation become clear. In winter and spring vehicle and industrial filters contribute significantly to the target products. In spring and summer, paints and household cleaning and maintenance products are noticeable at between 0.05 and 0.5% of the waste stream.

INTRODUCTION

Municipal landfills are receiving small quantities of hazardous products and wastes that may contribute to the contaminant loading of leachate and gas emissions. While recycling of paper, glass, metals, etc. may reduce landfill space requirements, removal and proper management of hazardous products may more effectively eliminate health risks and environmental impacts from local landfills. Furthermore, some communities are considering the possibility of hosting hazardous waste transfer stations to collect hazardous products. An analysis of the generation and disposal of the hazardous components is needed in order to make a rational choice of the best management system for rural communities.

The goal of this research is to estimate potentially hazardous product loadings in a rural landfill by sampling and determining mean weights and variation of discrete components in the waste stream. The necessary tasks were completed in the following sequence: 1. Select and describe the community and the surrounding area by its residential, business and industrial sectors to identify waste generating activities; 2. Describe the waste management system including conduct a sampling program to measure hazardous products by source area; 4. Analyze the results with statistical procedures to determine quantities and variation by area and source to identify patterns; 5. Draw conclusions and outline the implications for planning.

THE STUDY AREA - A RESOURCE-BASED COMMUNITY IN ALBERTA

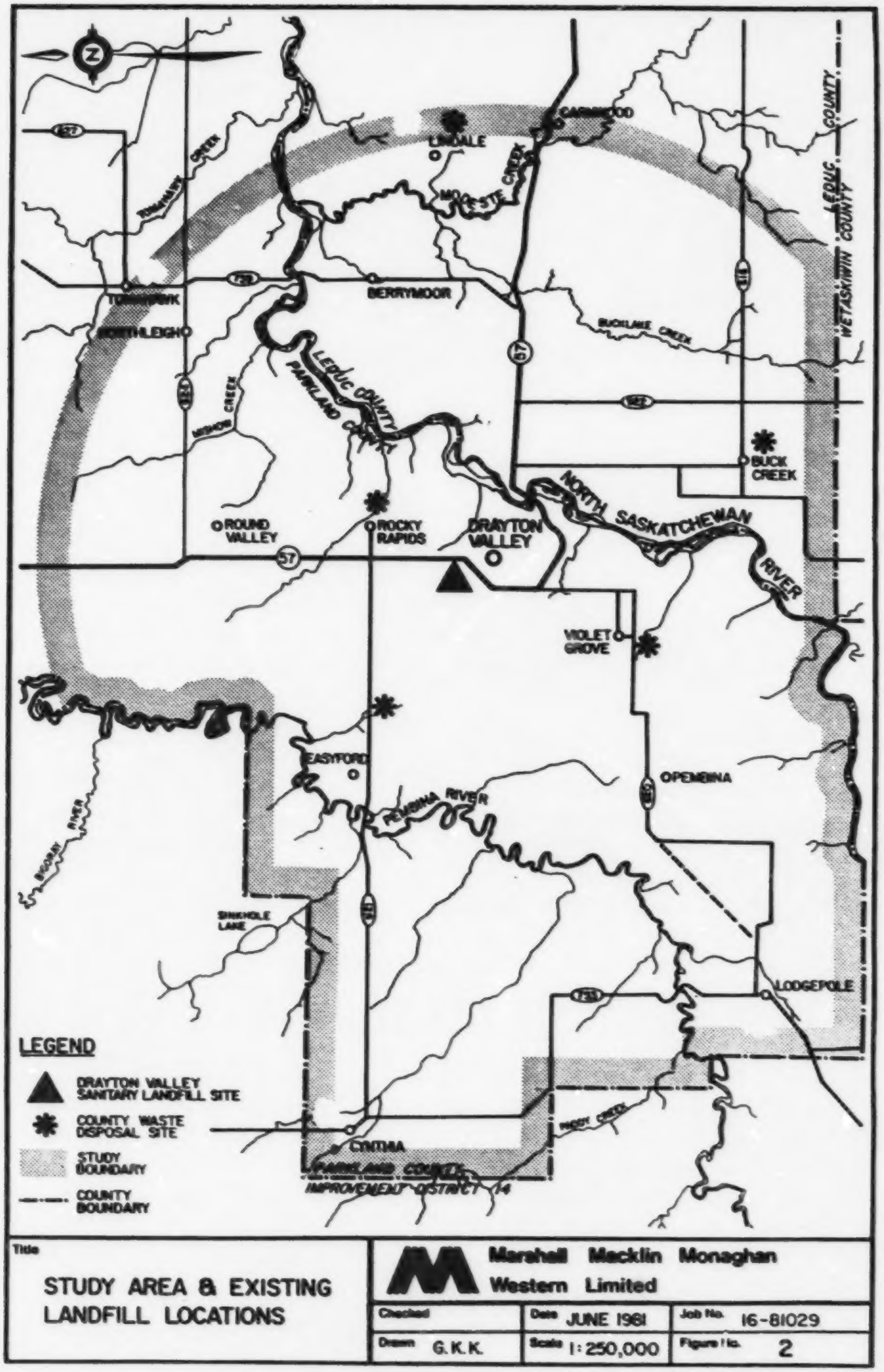
The Town of Drayton Valley, Alberta was selected for this study because of its size, its location and its economic base in the oil industry the opportunity to decide whether to host a hazardous waste transfer station for the region. Drayton Valley is a small community of about 6,000 residents, 150 km west of Edmonton in the oil patch. The community has in operation a landfill to service the town and the surrounding areas, so the waste stream can be easily identified and analyzed.

The Town of Drayton Valley is the primary trading, residential and service center for the Pembina oil field with over 8,000 wells, 80 gas plants and 1,500 oil production facilities. The forest industry is represented through sawmills and a board plant. Agriculture forms the third sector with 850 farms with an average of 480 acres each in the surrounding municipal District (M.D.) of Brazeau. In the town itself, trucking (32), construction (82), oilfield services (70), industrial and business services (60) as well as retail, residential and automotive service shops are most frequent. In 1989, 5,500 residents lived in the town proper with 5,448 residing in the surrounding hamlets and areas in the M.D. Most residents (68%) live in single family detached homes and most (71.2%) own their own homes, compared with the Alberta provincial averages of 63% and 62%, respectively. Mobile homes constitute 11% of the housing stock in Drayton Valley, compared with the provincial average of 3%. In Drayton Valley, about 45% of residents moved into the community less than five years prior to the 1986 census, while province-wide, only 23.2% immigrated. While income, type and ownership of homes shows some community stability, the mobility compares with other resource-based communities (see e.g., Swan Hills, Chem-Security, 1991). The character of Drayton Valley is therefore fairly typical for resource-based communities which are oriented towards one or two industries.

THE MUNICIPAL WASTE DISPOSAL SYSTEM AND FACILITIES

In order to properly design a waste stream sampling program for hazardous wastes, the collection, transfer and disposal system is described. The study area is serviced by a system of 8 unattended rural transfer stations and one landfill near Drayton Valley. The transfer stations consist of a ramp and a 30 yd^3 dropboxes that are exchanged approximately twice to five times per week. In addition to the transfer bins, some residences in the M.D. are collected by commercial pickup with 12 yd^3 compaction trucks. The balance of waste is transported by small residential or business vehicles to the landfill site. All residences in the town are collected by commercial collection vehicles 24 yd^3 on a weekly basis. In addition, businesses and apartments have bins emptied weekly. Finally, some residents with special loads and some businesses and industries often haul their own wastes to the landfill, as do .

The landfill serves as a regional landfill for disposal of wastes from the area within 22 km of Drayton Valley. The site encompasses acres and includes buffer zone, scale house and access road. The disposal costs including hauling average $18.15 (1989) per tonne for town garbage and


Z
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LINDALE
CARNWOOD
MODESTE CREEK
759
TOMAHAWK
BERRYMOOR
NORTHLEIGH
616
22
MISHOW CREEK
LEDUC COUNTY
PARKLAND COUNTY
BUCKLAKE CREEK
LEDUC COUNTY
WETASKIWIN COUNTY
BUCK CREEK
NORTH SASKATCHEWAN RIVER
ROUND VALLEY
ROCKY RAPIDS
DRAYTON VALLEY
57
VIOLET GROVE
EASYFORD
PEMBINA RIVER
OPEMBINA
BIGORAY RIVER
SINKHOLE LAKE
LODGEPOLE
753
CYNTHIA
PARKLAND COUNTY
IMPROVEMENT DISTRICT 14
LEGEND
DRAYTON VALLEY SANITARY LANDFILL SITE
COUNTY WASTE DISPOSAL SITE
STUDY BOUNDARY
COUNTY BOUNDARY
Title
STUDY AREA & EXISTING LANDFILL LOCATIONS
Marshall Macklin Monaghan Western Limited
Checked
Date JUNE 1981
Job No. 16-81029
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Figure No. 2

Figure 1. Map of Waste Management Area

$35 per tonne for rural garbage. Residential and small business vehicles are weighed, paid through taxes, but not charged, while large collection vehicles and industrial haulers are.

The sanitary landfill is operated as an area fill with some initial excavation for the cells. No leachate or gas collection systems are installed, but groundwater monitoring wells are tested once yearly. Approximately 20,000 tonnes per annum of waste are disposed of in this landfill. The waste stream consists of over 50% mixed residential and commercial garbage, 12% demolition waste and 38% soil and cover material. Since the focus of the study is on discrete hazardous products in the refuse stream, demolition and soil wastes are not included here. The arriving refuse weights vary seasonally with peak values of 1,000 to 1,200 tonnes per month in May through October, (spring, summer and fall), and low values of 600 tonnes per month from November through April (winter). The number of vehicles varies seasonally with high values of 600 vehicles per week in spring and summer, and low numbers of 130 to 150 vehicles in the winter sampling period.

STUDY METHODOLOGY

The objectives of the study call for sampling and analysis of discrete items and products in the refuse fraction of the waste stream. This material arrives at the landfill from diverse and dispersed sources. As a result, sampling of loads at the landfill was selected over sampling waste loads at curbside.

In order to minimize variation within groups of vehicles the vehicle loads were stratified into twelve categories to reflect source area (town versus M.D.), waste generating activity (residential, business and industrial), and size of load (that is, over or under 1,000 kg). Furthermore, seasonal differences were to be determined so that four sampling weeks were selected to reflect typical seasonal characteristics and weights in February (winter), May (spring), July (summer) and October (fall).

Based on previous experience and the availability of dig, weigh and sort samples and separate hazardous products, it was estimated that 30 to 40 samples of approximately 90 to 140 kg (Klee, 1980) each could be processed in a six day work week. These were initially allocated among vehicle groups according to waste weights. It became apparent in the first sampling period, that 50 to 70 loads could be sampled, particularly because the small loads contained less waste and were more easily sampled. The primary objective was to identify hazardous product content from within the town. As a result, all 12 to 16 large town loads were sampled, while large rural loads and small vehicles were systematically random sampled to make up the balance of available sampling capacity.

Large loads from collection vehicles, transfer stations and commercial containers were sampled by flattening and spreading the load in a one meter thick layer over an area of approximately 4.5 times 12 metres. The load was then divided into 1.5 m square cells and the cells were numbered. Depending on the weight of the load, one, two or three cells were selected with random numbers, were dug, weighed and sorted. The sample weights averaged 110 to 165 kg, approximately within the recommended range of 90 to 140 kg (Klee, 1980). Entire small loads were entirely off loaded, weighed and sorted.

Table 1 - Product Groups for Waste Stream Analysis

Product Group No.	Waste Type
1	Oil Rags and Debris
2	Motor Oil Containers
3	Filters, industrial and motor
4	Used Oil
5	Automotive Products
6	Household Cleaning Products
7	Bathroom Cleaners
8	Waxes, Polishes
9	Laundry Products
10	Enamel Paint
11	Latex Paint
12	Adhesives
13	Cologne, Perfume
14	Hair Spray, Mousse, Perm Solution
15	Batteries
16	Prescription Drugs
17	Flammables
18	Solvents, Thinners
19	Dishwashing Detergents
20	Inks, dyes
21	Pesticides, Fertilizers

During the sorting process, all bags were opened and the contents separated. All potentially hazardous products were removed, weighed and classified by product group, brand and container size.

The extracted products were classified into 21 product groups. These groups are listed and described in Table 1. The 21 groups are similar to other listings (Robertson et al., 1987, Savage and Sharpe, 1987, Jones and Atwater, 1991)) and cover all household and commercial products that were found in the waste samples.

Containers in most groups were kept for determination of the residue weights.

RESULTS

The objectives of the study are primarily to identify the fraction of discrete hazardous products in the municipal waste stream and to determine predominant sources and products. The results are summarized here under these two headings.

Hazardous Product Weights

The contents of hazardous products in the municipal waste stream are presented as the weekly mean weight fraction and the standard error of the mean weight fraction (both in % of total weights). The stratified sampling procedure allows the mean and standard error values to be determined for each vehicle group (or stratum) for each week (see Table 2).

Hazardous products in small vehicles range from a low of 1.3 % to a high of 16.8 % by weight. Higher mean weights also have higher variation. Since the loads are generally small, however, single heavy items (e.g., car batteries) or single loads with significant hazardous product weights can skew the distribution. Generally, though, the small vehicle loads, particularly in spring, contain low percentages of hazardous products, usually between 1.3 to 3.9 percent.

Large loads from town collection vehicles and large commercial loads appear far more consistent with 3.02 to 3.7 percent of their loads consisting of hazardous products and standard errors of the mean hazardous product fraction ranging between 0.44 and 0.87 percent. These values are consistent the seasons. The contents of large rural loads varies between 3.0 and 17.4 percent, again possibly due to individual items or loads affecting the results. In addition, due to smaller sample numbers in this stratum the diversity of sources may influence these results.

The weighted weekly means and standard errors over all vehicle groups are estimated from the weight fractions delivered to the landfill by each vehicle group and are listed in the bottom row of Table 2a,b and c. The between weekly variance of the means are calculated in the right hand column. The former results are accurate estimates of the mean and variation of hazardous products in the specific waste stream. The estimates of the standard deviations may serve as initial estimates for designing a similar sampling program elsewhere (see Klee, 1980).

Products and Sources

The predominant hazardous products by weight (i.e., over 0.1% weight fraction of the waste stream) consist of motor oils, vehicle oil filters and industrial oil and gas filters, enamel and latex paints and debris, adhesives and batteries (see Figures 2, 3 and 4). Most of these products arrive either in private vehicles or in collection vehicle loads, while industrial filters stem from transfer station loads from the areas where oil and gas plants are clustered. Other products flow in regular and low weights into the landfill. There appear to be some seasonal differences in the weights for filters and paints during winter and summer, respectively. This is likely due to seasonal maintenance activities for automobiles and homes.

Table 2a - Hazardous Products - Seasonal Means and Standard Errors in Winter

Vehicle Type	Mean %	Standard Error of Mean %	Waste Weight Sampling Week
Small			
Residential	6.8	9.14	3,860
Commercial	3.9	1.84	13,220
Large			
Collection - Town	3.7	0.44	47,920
Collection - Rural	(17.4)*	n.a.	12,830
Industrial	0.6	n.a.	1,400
Season Mean	6.54		79,230 kg
Season Standard Error of Mean		0.23	
95% Confidence Range of Seasonal Mean	6.09 - 6.99		

* One load

Table 2b - Hazardous Products - Seasonal Means and Standard Errors in Spring

Vehicle Type	Mean %	Standard Error of Mean %	Waste Weight Sampling Week
Small			
Residential	2.68	1.34	43,770
Commercial	2.55	1.50	11,740
Large			
Collection - Town	3.02	0.87	77,158
Collection - Rural	(14.68)**	7.61	100,160
Industrial	0.6	______	0.000
Season Mean	7.86		235,987 kg
Season Standard Error of Mean		1.51	
95% Confidence Range of Seasonal Mean	4.9 - 10.82		

** includes 2 car batteries

Table 2c - Hazardous Products - Seasonal Means and Standard Errors in Summer

Vehicle Type	Mean %	Standard Error of Mean %	Waste Weight Sampling Week
Small			
Residential	1.30	1.00	27,960
Commercial	8.90	7.64	35,380
Large			
Collection - Town	3.2	0.7	80.870
Collection - Rural	3.9	1.9	104,490
Industrial	0	0	0.000
Season Mean	4.05		251,170 kg
Season Standard Error of Mean		0.57	
95% Confidence Range of Seasonal Mean	2.93 - 5.17		

* One load

** includes 2 car batteries

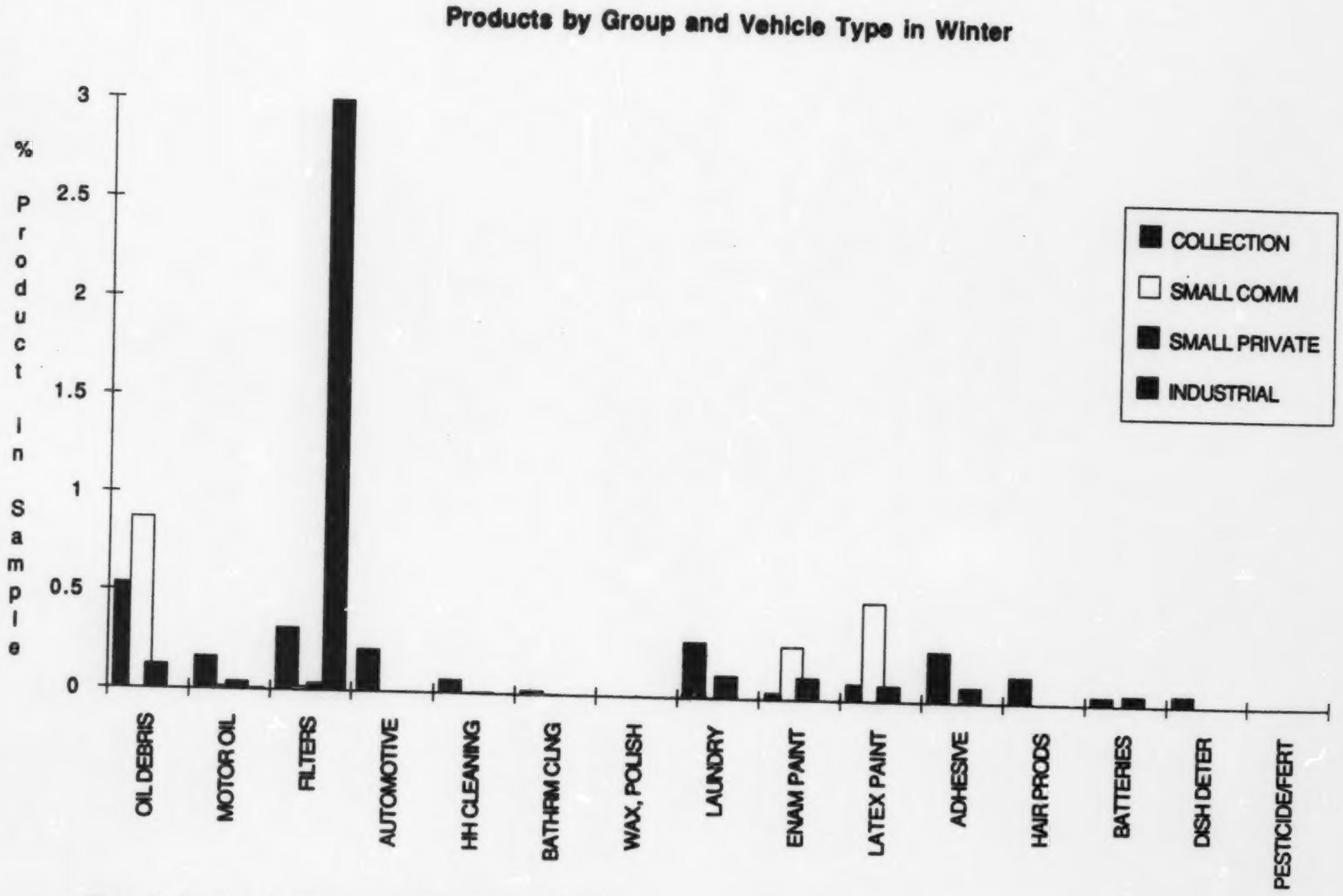

Figure 2. Products by Group and Vehicle Type in Winter

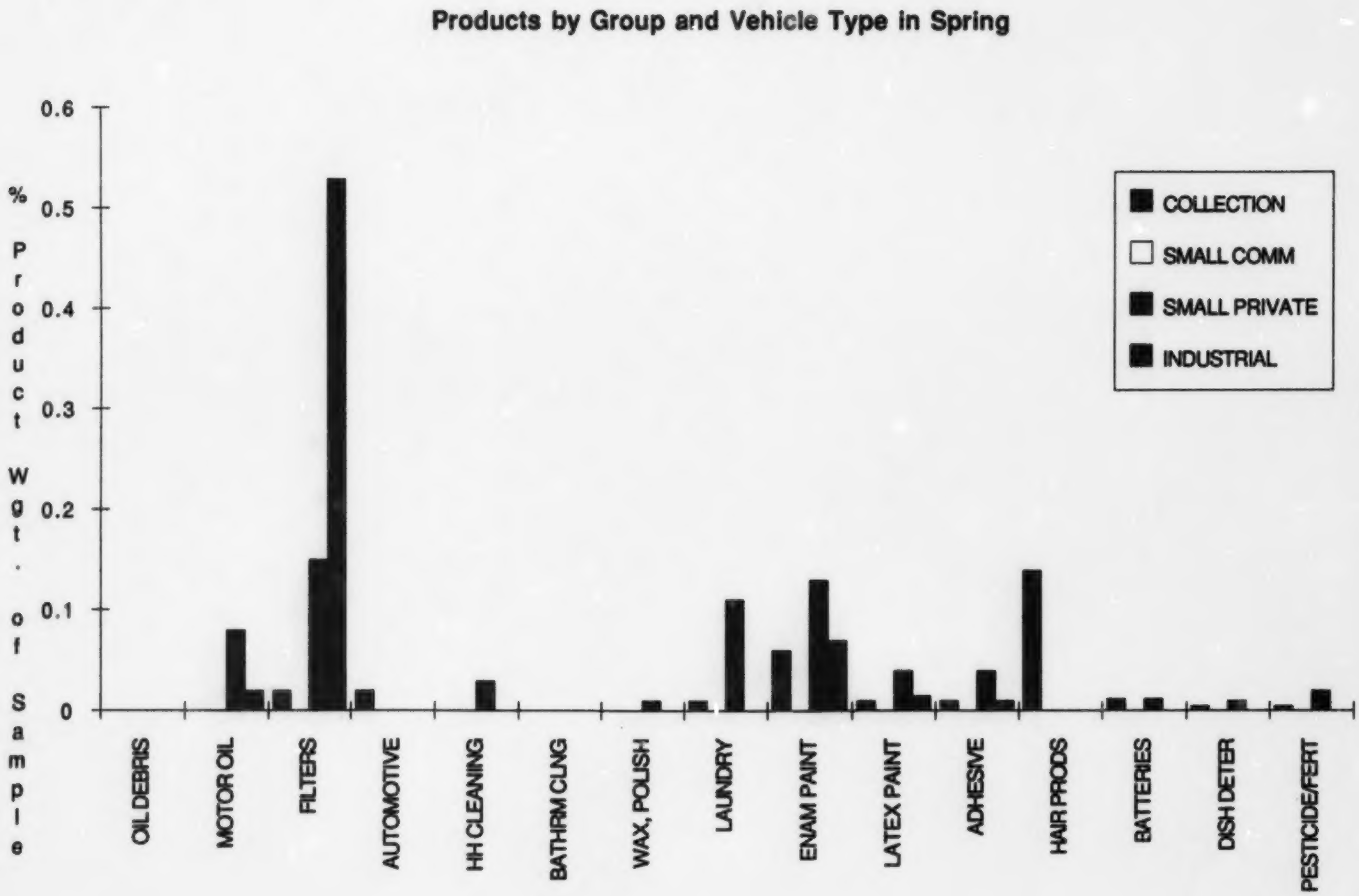

Figure 3. Products by Group and Vehicle Type in Spring

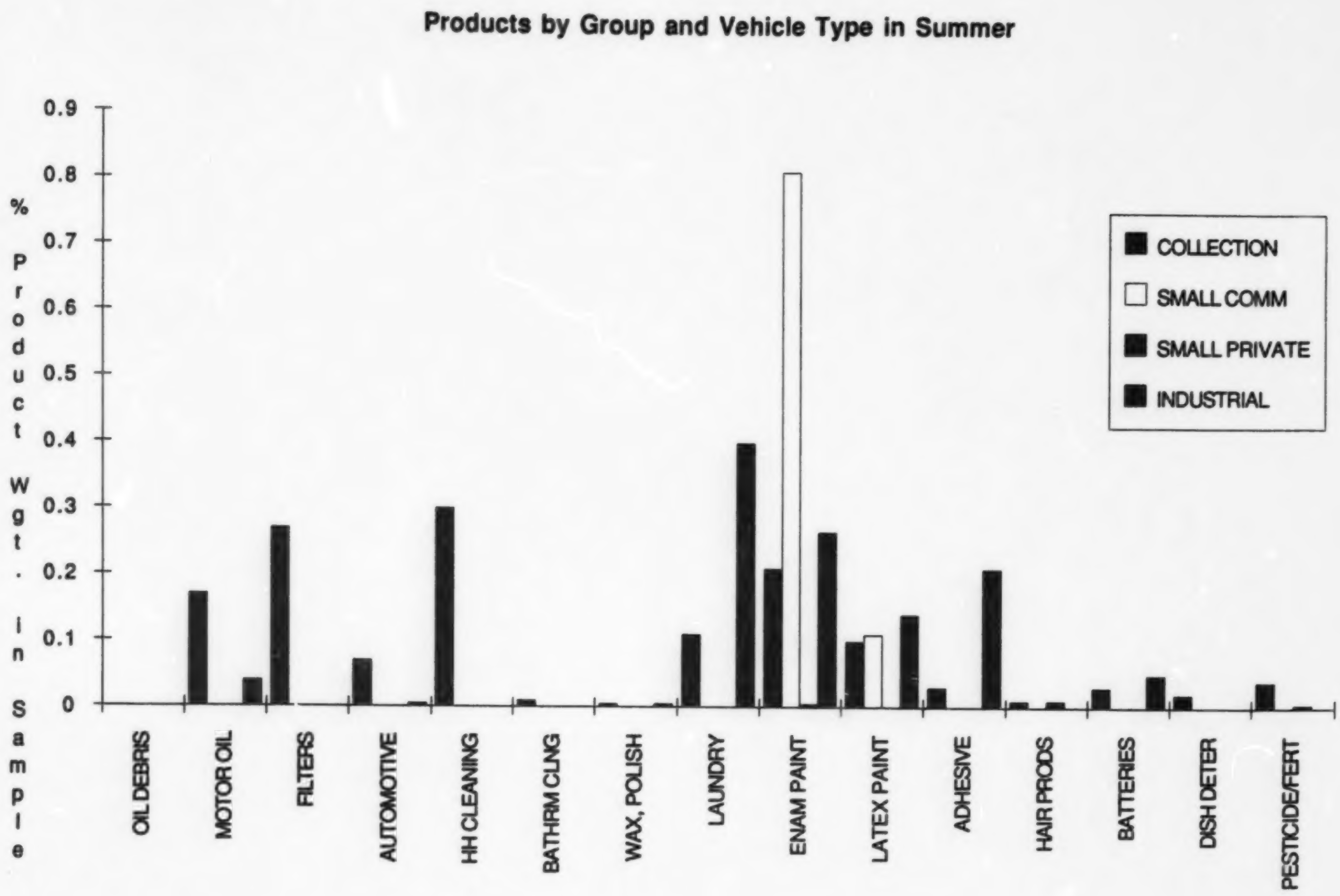

Figure 4. Products by Group and Vehicle Type in Summer

DISCUSSION

Overall the results are somewhat higher than expected with average weights of hazardous products significantly above 3 % by weight of the waste stream. This is significantly higher than previously reported values of 0.0 % to 1 % (Wilson and Rathje, 1989, Morse, 1988, Jones and Atwater, 1991). While some previous studies did not include container weights, this study still shows higher values than the studies that did. While this study area comprises mainly small town and rural land uses and includes many farms and acreages, the other studies were conducted mainly in metropolitan areas (e.g., Vancouver, B.C., New Orleans, LA, Seattle, WA, Marin County, CA, etc.). Furthermore, the economic activities in an oil resource-based community certainly contribute to the loading of industrial filters and vehicle filters. Even without these industrial components, however, the household and small business hazardous products amount to about 3 %.

These values have to be modified to reflect actual content weight and some measure of harmfulness (e.g., toxicity) for the purpose of estimating the actual contribution of hazardous substances in potential landfill impacts. However, for the purpose of planning a local collection depot or a transfer station, these figures are relevant and useful.

CONCLUSIONS

The contribution of small quantities of hazardous products including containers constitute over 3% of municipal waste stream in the resource-based community in Western Canada. While large (i.e., over 1,000 kg) residential collection vehicle loads consistently contain 3.0 to 3.7% of hazardous products, small private and commercial vehicles as well as large loads from rural transfer station drop bins contain fluctuating quantities of potentially hazardous products as high as 17% of weight. These loads are, however, often strongly affected by few heavy items or large quantities in a drop from one source. Household use products such as detergents, polishes, cleaning materials, hair products appear fairly consistently throughout the three seasons, while vehicle and industrial filters are significant in winter and spring and paints predominate in summer.

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DISCLAIMER

The comments in this article are for information and discussion purposes only and are not to be relied upon in any particular situation without the express written consent of the author.

Waste Paint Becomes New Paint: Paint Recycling Comes to Ontario

(La vieille peinture fait peau neuve:
le recyclage de la peinture
arrive en Ontario)

Claudia Marsales
Laidlaw Environmental Services Ltd.
Mississauga, Ontario

Paper unavailable at time of printing
Texte non reçu au moment de mettre sous presse

HOUSEHOLD HAZARDOUS WASTE – HOW MUCH IS REALLY OUT THERE?

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Some of the research described in this paper was funded by the Ontario Waste Management Corporation, and was carried out while Ms. Kelleher worked with CH2M Hill Engineering Ltd. of Mississauga, Ontario.

1 *INTRODUCTION*

Liquid industrial and hazardous wastes generated by industries, commercial establishments and institutions are generally regulated in some manner, whereas the small portions of these same wastes generated by households are generally disposed in the garbage or down the sewer in an unregulated manner. When one considers the large number of households in North America, each contributing a small amount of liquid and hazardous waste each year, the quantity of HHW disposed is of significance. But what is this quantity?

There are two possible approaches to estimating the quantity of HHW generated each year. These are:

a) Look at the "front end" of the system, by analysis of residential garbage to determine the quality and quantity of HHW generated,or

b) Look at the wastes delivered to HHW collection depots as a reflection of what is likely to be contained in all households.

TABLE 1

MATERIALS USED BY HOUSEHOLDERS WHICH CONTAIN HAZARDOUS CHEMICALS

Antifreeze	Household Ammonia
Engine Oil	Laundry Detergent
Auto Wax/polish	Metal Polish
Batteries, Auto	Nail Polish
Batteries, General	Nail Polish Remover
Carburettor Cleaner	Oven Cleaner
Cleanser	Paint
Dishwashing Detergent	Paint Stripper
Disinfectant	Paint Thinner
Drain Opener	Pesticides
Engine Degreaser	Rust Preventer
Fertilizer	Rust Remover
Floor Cleaner	Solvent
Floor Wax	Toilet Bowl Cleaner
Furniture Polish	Varnish
Glass Cleaner	Wood Putty
Glue	Wood Sealer
Herbicide	Wood Stain

This paper discusses the data available from both of these approaches, and also from a survey which looked at both the generation and disposal aspects of HHW.

2. *BACKGROUND*

Table 1 lists a number of commonly used household products which contain hazardous chemicals. The traditional method of disposal for small quantities of these products which would remain in containers was either to throw them in the household garbage or down the drain. Concern over both of these disposal methods has increased since the early 1980's. This has prompted the establishment of a number of HHW collection programs. These have occurred either at one day drop-off centres, or at permanent depots. Table 2 illustrates the obvious increasing trend in HHW collection programs. In the U.S. there were 2 programs in 1980, 175 in 1985, 483 in 1988, and 855 in 1990.

TABLE 2

NUMBER OF HOUSEHOLD HAZARDOUS WASTE COLLECTION PROJECTS IN THE U.S. 1980-1990.

Year	Number of HHW Collection Programs
1980	2
1981	4
1982	8
1983	31
1984	94
1985	175
1986	273
1987	299
1988	483
1989	692
1990	855
	Source: Household Hazardous Waste Management News. March 1991

In Ontario, the Provincial Ministry of the Environment has been funding HHW collection programs since 1986. The funding requests from municipalities who run these programs have increased from 9 in 1986 to 58 in 1991. With the increased focus on HHW collection it is amazing how little is known about the actual generation rate for this material. The available estimates vary, and are compared in the next section.

3. *ESTIMATES OF HHW GENERATION*

3.1 USEPA 1980 , and Other "Rule of Thumb" Estimates

In 1980, the USEPA estimated that HHW accounted for 1% of municipal garbage. If you apply this percentage to an average Ontario household, which produces an estimated 1,200 kg. of municipal solid waste (MSW) per year, the result is an estimated 12 kg/year of HHW per household. This compares to an estimate of 6.8 kg/year (15 lbs/year) commonly used as a rule of thumb for HHW generation. (Reference: Garbage magazine, March-April 1990).

3.2 CANVIRO/OWMC 1988 Estimate

In 1986, the Ontario Waste Management Corporation contracted CANVIRO Consultants to estimate the amount of HHW produced by households in Ontario, a province with approximately 3.2 million households, and a population of 9.1 million at that time. CANVIRO developed the estimate based on generation rates found in a literature survey carried out in December 1986.

The HHW generation rates developed by CANVIRO as well as the references from which the generation rates were derived, are presented in Table 3 below:

TABLE 3

CANVIRO ESTIMATE OF HOUSEHOLD HAZARDOUS WASTE GENERATION

Waste Type	Generation Rate (Kg/household/year)	References
Paint Waste	5.0	Blackmar, D.S. (1984)
Spent Solvents	0.9	Blackmar, D.S. (1984)
Used Oils	12.0	Tiffany, H.E. (1982)
Anti-freeze	4.2	Rathje, W.L. (1986)
Pesticide Wastes	1.6	Blackmar, D.S. (1984)
Other	1.6	Blackmar, D.S. (1984)
TOTAL	25.3	CANVIRO (1988)

The Blackmar (1984) report presented results of a regional hazardous waste collection program conducted in 15 towns in Barnstable County, Massachusetts. In total, 375 households responded to the collection drive. This report provided a detailed breakdown of the various types of wastes collected, and was therefore used to develop annual generation rates for paint wastes, spent solvents, pesticide waste and other miscellaneous wastes, as this type of breakdown was required for the CANVIRO study.

In order to develop generation rates for the above waste categories, it was necessary to assume a time span over which the homeowners accumulated the wastes that were collected during the study. Based on the fact that approximately 67 percent of the study area population were summer residents, it was felt that clean-up of HHW would be performed less frequently than it would be in a "typical" residential area. A time span of 5 years was assumed, based on discussions with a member of the study team.

The generation rate for antifreeze was obtained from the Rathje (1986) study. This was the only study to identify a generation rate for antifreeze.

The generation rate for used oil was obtained from Tiffany (1982). This paper estimated that the annual volume of used oil disposed by homeowners in the United States was 260 million U.S. gallons. This was divided by the number of households in the U.S. (74 million at that time) to produce an average used oil generation rate of 12 kg/household/year. The generation rate obtained from this report was felt to be most appropriate, as it fell within the median of the range of generation rates obtained from a number of other studies.

3.3 Rassbach 1989 Estimate

In March 1989, an article in Environmental and Waste Management World calculated that the annual generation of HHW was 9.7 kg/household. This conclusion was reached by comparing results of a number of waste sorting studies in Marin County, New Orleans and Puget Sound. The average HHW residue generation rate identified by these studies was 4 kg/year. A "container factor" of 5.7 kg/year was added to the HHW residue generated to reach a total HHW generation rate of 9.7 kg/household/year. Of this total, the article estimated that 2 kg/year (20.4%) was waste oil and 3.8 kg/year (39.5%) was paint waste. The breakdown of waste types estimated by this study are summarized in Table 4.

TABLE 4

COMPOSITION OF HHW ESTIMATED BY RASSBACH (1989)

Material	Generation Rate (Kg/year)	% of Total
Waste oil	2	21
Paints	3.9	40
Solvents	0.6	6
Pesticides	0.2	2
Inorganic cleaners	0.9	9
Batteries, elec. parts	0.8	8
Organic liquids incl. antifreeze	0.3	3
Cosmetics, medicines etc.	0.4	5
Other	0.6	6
TOTAL	**9.7**	**100**

Reference: Rassbach, Environmental and Waste Management World, March 1989.

3.4 Jones and Atwater, 1990 Estimate

A paper was presented at the 1990 CSCE Annual Conference describing the results of a study carried out in Vancouver, British Columbia, Canada, a city of about 186,000 households. The study involved a survey of households in three socio-economic zones of the city. Householders were asked a number of questions regarding:

- how much HHW they currently store in their homes
- how they typically dispose of HHW (garbage, drain, on ground etc.)
- how much HHW they produce per year, divided into 18 categories

166 survey responses were received. The data was extrapolated to estimate:

a) the average amount of HHW stored in each home, and
b) the average amount of HHW generated by each home on an annual basis

Table 5 shows the estimated annual HHW generation per household determined by the Jones et al study. Other studies have noted that householders tend to underestimate the amount of HHW they generate. The Jones et al data confirm this observation. The estimate of 3.4 kg of liquid waste is lower than estimates developed by other sources.

TABLE 5

ESTIMATED ANNUAL HHW GENERATION BY HOMES IN VANCOUVER, B.C. (JONES ET AL, 1990)

Waste Type	Average Quantity Generated per Household per Year
Liquid*	3.4 kg
Batteries	5.5 units
Lead-Acid Batteries	0.05 units
Prescriptions	0.2 units
Smoke Detectors	0.03 units

*Liquid includes cleaners, drain openers, latex paint, oil based paint, wood preservative, paint thinner, adhesives, pesticides, motor oil, antifreeze, fuels, petroleum products, pool chemicals, acids and bases.

3.5 The Garbage Project Composition Estimate

An estimated composition of HHW developed by The Garbage Project was presented in the March/April 1990 issue of Garbage Magazine. This is summarized in Table 6, and is somewhat different to other estimates, as it presents a lower figure for used oil, at an estimated 10% of the waste stream, and a figure of 18% for batteries.

TABLE 6

ESTIMATED COMPOSITION OF HHW AT SOURCE BY THE GARBAGE PROJECT (1990)

Material	Estimated Percentage of HHW Stream
Household maintenance (mostly paints, thinners, adhesives)	36.6%
Household batteries	18.6%
Personal care products (including nail polish, remover, hair spray, deodorant)	12.1%
Automotive maintenance products (mostly oil)	10.5%
Pesticides, (plus pet supplies, fertilizers)	4.1%
Hobby,/Other (includes pool chemicals, lighter fluid, art supplies)	3.4%
Pharmaceuticals	3.2%

TABLE 7

SUMMARY OF HHW GENERATION RATES

Reference	Estimated HHW generation rate (kg/year)
USEPA (1980)	12
"Rule of Thumb"	6.8
CANVIRO (1988)	25.3
Rassbach (1989)	9.7
Jones et al (1990)	3.4 (liquid)

3.6 Summary of Data Available on HHW Generation at Source

3.6.1 Waste Quantity

Estimates of HHW developed by looking at the front end of the waste generation cycle are summarized in Table 7. These vary from a low of approximately 3.4 kg/year by Jones et al, to a high of 25.3 kg/year estimated by CANVIRO.

3.5.2 Waste Quality

Estimates of the composition of HHW generated at source vary. Four sets of composition data were presented in the previous section. A detailed comparison of the estimates is not possible, as wastes are grouped together differently in each case, hence limiting comparison to those waste groups which are similar. There is some agreement that pharmaceuticals and pesticides make up a small fraction of the HHW stream, at estimates of 5% and 2-4% respectively. There is also agreement that paints make up a significant fraction of HHW with estimates varying from 25-40%. There is a wide variation on the estimates of used oil as a percentage of the HHW stream. This may be because of the methodology used in different studies. Waste sorting studies only capture the quantity of used oil disposed in the garbage, whereas large amounts may also be improperly disposed by dumping on the ground, or down the sewer system. However, these wastes are generated by homeowners, and should be captured by HHW collection programs.

4. MATERIAL COLLECTED BY HHW COLLECTION PROGRAMS

4.1 Quantity of HHW Received

As stated previously, HHW collection programs are dramatically increasing in number in both Canada and the U.S. Data on the number of households participating in a number of programs, and also the quantities of HHW collected, were examined to see if any consistent pattern, or HHW generation rate, could be established. The generation rate for a number of programs are presented in Table 8. The table shows consistently high generation rates for each of the households participating in the programs. The table also shows that reported average rates for relatively large programs vary from a low of 19 kg/participant in Albequerque, New Mexico, to a high of 62.4 kg/participant for a permanent depot in Mississauga, Ontario in 1990. When one looks at the detailed data, exceptionally high generation rates are evident in some areas. For example, the detailed 1988 Ontario data show that six of the sixty three programs averaged rates between 80 and 93 kg/participant. The 1989 Ontario data indicate four of the 43 HHW collection programs reported rates of 124, 129, 139 and 203 kg/participant. These were predominantly in rural areas.

The figures noted probably do not reflect typical annual HHW generation, as it is likely that people clean out their basements of old paint etc. which may have been sitting there for a number of years when they decide to visit a HHW depot. As an example of the unusual waste materials that turn up at these programs one program in Arizona received a Geiger counter from one participant, and the next car contained some uranium yellow cake, a radioactive waste brought in by the wife of a deceased metallurgist who had used it as a display sample.

The figures quoted may not reflect the amount of HHW produced by a household each year, but they are a good indication of what to expect when designing a permanent depot. Operators of permanent HHW depots or one day collection drives have typically observed.

- very low participation rates, in the order of 1-2% of households
- very large quantities of HHW deposited by each participant

A study carried out in Vancouver, British Columbia asked householders two questions related to this issue, namely:

- how much waste is currently stored in your home? and
- how much HHW would you produce on an on-going annual basis

The householders estimated that they had approximately 3.5 kg of liquid HHW, and miscellaneous batteries, prescriptions, and other solid HHW in storage in their homes, which would be captureed by a first time HHW collection program. They estimated that on an on-going basis, each household would produce 3.4 kg of liquid HHW per year, along with 6 batteries and small quantities of other solid HHW. Rathje (1990) has concluded that householders tend to underestimate the amount of waste they produce themselves, hence the above figures are likely an underestimate.

Dana Duxbury (1990) quoted the average HHW generation rate of American households as 15 lbs/year, compared to an average of 116 lbs/participant delivered to HHW collection depots. The explanations for this difference were that each participant may represent more than one household, and also, the data included first time collections to which people bring years of accumulated waste. These quoted rates represent accumulations of at least 8 years of waste, if one assumes that each participant represents only one home, and that some HHW has been discarded in the 8 year time span.

4.2 Composition of HHW Received

The composition of the waste deposited at HHW collection programs is also of note. Table 9 presents four years of data for Ontario's HHW collection programs, and Table 10 presents data from two U.S. programs, in Hennepin County, Minnesota, and Palm Beach, Florida. The tables indicate that paint waste always makes up a significant proportion of the HHW collected. Waste paint made up 50% or more, of all wastes received at Ontario HHW Collection programs from 1986-1988. This lower percentage noted in 1989 reflects the fact that large quantities of miscellaneous organic wastes were collected by the programs. The rates of paint disposal by participants varied from 10 to 16 kg/participant for these four years. The data on U.S. programs shown in Table 10 indicate that paints, (oil and latex based) account for 42.7% of all wastes disposed at the Palm Beach facility, and 62% of wastes disposed at the Hennepin County facility.

Other programs have reported that waste oil makes up a significant proportion of the collected HHW. This does not appear to be the case for Ontario, where over a 4 year period of data, it made up 3-16% of the collected waste stream. By contract, waste oil made up 17.5-22.7% of the waste collected in the two U.S. programs.

TABLE 8
SUMMARY DATA FROM A NUMBER OF HHW COLLECTION PROGRAMS

HHW Collection Program Location	Quantity of Waste Collected (kg)	Number of Participants (Assume Households)	HHW Collected Per Household (kg)
Hennepin County, Minnesota 1990	237,802	10,000	23.8
King County, Washington	484,090	17,021	28.4
Albuquerque, N.M. 1990	38,363	2,015	19.0
Florida	1,441,590	30,000	48.0
Palm Beach	109,545	2,000	54.8
Melbourne, Australia	169,090	5,000	33.8
Ontario 1986	34,870	1,338	26.1
Ontario 1987	100,509	2,958	34.0
Ontario 1988	188,003	8,822	21.3
Ontario 1989	970,101	21,364	45.4
Metro Toronto 1989	215,550	7,797	27.6
Metro Toronto 1990	513,000	15,950	32.2
Mississauga Permanent Depot 1989	157,018	2,941	53.4
1990	229,443	3,678	62.4
Mississauga Waste Day 1989	28,310	1,059	26.7
Caledon Waste Day 1990	13,249	337	39.3

TABLE 9
COMPOSITION OF HHW RECEIVED AT ONTARIO HHW COLLECTION FACILITIES

year	avg. kg/ participant	paint	misc inorg.	solvents and fuels	pesticides	crank case oil	misc org.	comp. gases
1986	26	60%	9%	7%	5%	16%	2%	1%
1987	34	47%	13%	10%	6%	3%	19%	2%
1988	21	53%	13%	6%	5%	10%	10%	3%
1989	45	23%	9%	3%	5%	15%	43%	1%

Source: Ontario Ministry of the Environment Waste Management Branch

TABLE 10

COMPOSITION OF HHW RECEIVED AT SELECTED U.S. PROGRAMS

	avg. kg/ partic-ipant	Oil Based Paint	Latex Paint	Used Oil	Batteries	Pestic-ides/ Poisons	Other
Palm Beach	54.8	24.2%	18.5%	22.7%	9.6%	2.9%	22.1%
Hennepin County, Minnesota	23.8	31%	31%	17.5%	9.6%	3%	7.9%

Pesticides generally appear to account for 3-6% of the wastes collected in the two U.S. programs examined. Data on battery weights were not available for the Ontario programs.

5. *SUMMARY AND CONCLUSIONS*

This paper has attempted to summarize available data on household hazardous waste generation, and the quantities of HHW deposited in HHW collection programs in the U.S. and Ontario. The research has concluded that a direct correlation between HHW generation and HHW collected by these programs is not obvious.

The suspicion is that either significantly larger quantities of HHW are generated than previously believed, or significant quantities of HHW are stored by households throughout the U.S. and Canada.

Based on research to date, it is estimated that the quantity of waste stored averages out to 35 kg/household. In Ontario alone, this would equate to 136,500 tonnes of HHW in storage.

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